MAR 15 1924
English Library

Transactions of American Society for Steel Treating

Vol. V March, 1924 No. 3

SPECIAL FEATURES

Editorials 241

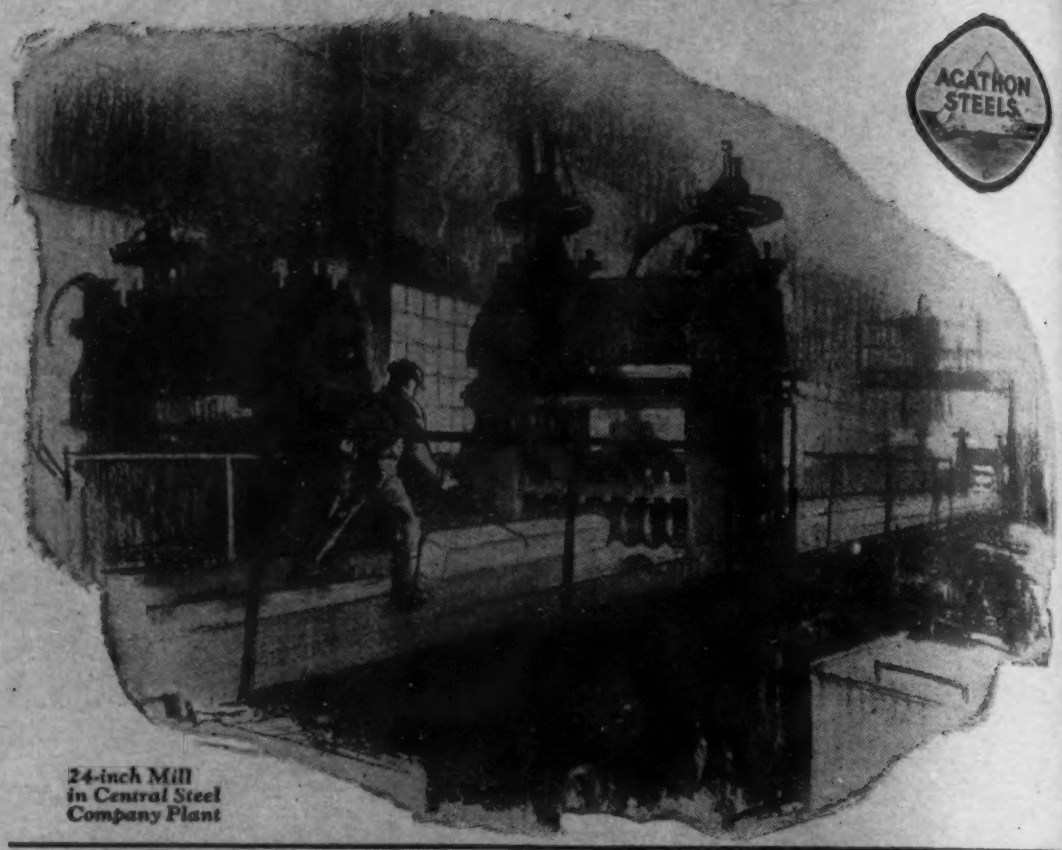
Physical Properties of Metals at Elevated Temperatures— *V. T. Malcolm* 256

Simplification and Standardization— *R. M. Hudson* 276

What is Case Depth?— *S. P. Rockwell and Frederick Downes* 285

Symposium on Metallurgical Education, Fifth Annual Convention, Pittsburgh— 302

Discussion of Convention Papers 317



24-inch Mill
in Central Steel
Company Plant

AGATHON ALLOY STEELS

OUR Metallurgical Department is maintained on the highest possible plane. It is abundantly supplied with the latest scientific equipment to be had and manned by a corps of expert metallurgical engineers and practical steel producers.

Through our years of experience in the production of commercial alloy steels this department has amassed and compiled a great amount of data on the adaptability of various special steels to hundreds of different lines of manufacture.

If a stronger, tougher or harder steel can be produced to meet the peculiar requirements of the highly stressed and excessive wearing parts of your product, our metallurgists can tell you and our mills can produce it. Write us. Get the co-operation of our organization and extensive facilities now. Remember it places you under no obligations.

We have daily production in all kinds of Agathon Alloy Steels such as—

Nickel, Chrome-Nickel, Uma, Molybdenum, Chrome-Molybdenum, Nickel-Molybdenum, Vanadium, Chrome-Vanadium, Chromium, etc.

Deliveries in Blooms, Billets, Slabs, Bars, Spring Flats, Hot Rolled Strips, etc.

THE CENTRAL STEEL COMPANY, Massillon, Ohio

Swetland Bldg. Cleveland | Book Bldg. Detroit | Peoples Gas Bldg. Chicago | University Block Syracuse | Widener Bldg. Philadelphia

TRANSACTIONS

of the

American Society for Steel Treating

Vol. V March, 1924 No. 3

THE SPRING SECTIONAL MEETING

IN ACCORDANCE with the decision of the Board of Directors of the American Society for Steel Treating at their meeting in Washington, Nov. 2, 1923, the Spring Sectional Meeting of the Society will be held under the auspices of the Tri City chapter, on May 22 and 23 at Moline, Ill., with headquarters at the LeClaire hotel.

The executive committee of the Tri City chapter, consisting of H. B. Bornstein, chairman of the Tri City chapter, C. H. Burgston, Mr. Henry, H. O. Koehler, C. A. Schoessel, C. H. Lage, J. F. Lardner, C. U. Scott, H. Brown and A. H. Putnam has conferred numerous times and has its plans well under way for this meeting. The chairman, H. B. Bornstein, has appointed the following committees which are now busily engaged in carrying out those steps necessary to insure a most successful and profitable meeting. PUBLICITY COMMITTEE: C. H. Lage, J. F. Lardner and Mr. Henry; FELLOWSHIP COMMITTEE: C. U. Scott; BANQUET COMMITTEE: H. Brown and H. O. Koehler; PAPERS AND PROGRAM COMMITTEE: C. H. Burgston; AUTOMOBILE AND PLANT VISITATION COMMITTEE: A. H. Putnam, and REGISTRATION COMMITTEE: C. A. Schoessel.

THURSDAY PROGRAM—MAY 22

The tentative plan of arrangements as drawn up by the several committees is as follows: On Thursday, May 22 there will be both a morning and afternoon technical session and on Thursday evening, there will be a banquet held jointly with the Tri City Manufacturer's association and the Tri City Engineers' club at

which time several notable speakers will be guests of the joint societies.

Friday Program—May 23

On Friday, May 23 the committees have planned a plant visitation for both the morning and the afternoon and have arranged to have plenty of automobiles available for the transportation to the various manufacturing plants and points of interest.

The committee has made arrangements with the Rock Island Arsenal Golf club so that a golf tournament will be held on the course beginning on Friday morning. Trophies have been arranged for, and it is expected that this golf feature will prove very attractive to a considerable number in attendance. The Rock Island Arsenal Golf course is one of the finest courses in the middle west, and the tournament should prove interesting to many. Bring along your clubs and have a good time.

Technical papers have been arranged for and the committee now has the assurance that they will have technical papers from Dr. Anson Hayes, Iowa State college, Ames, Iowa; C. B. Swander, metallurgist with the Wagner Electric Co., St. Louis; R. G. Guthrie, metallurgist with the Peoples Gas Light & Coke Co., Chicago, and J. H. Nelson, metallurgist with the Wyman-Gordon Co., Worcester, Mass.

Headquarters for the Spring Sectional meeting will be at the LeClaire hotel, which is a modern hotel having been completed about a year ago. This hotel is admirably equipped for such a meeting and has many very comfortable rooms at moderate rates. All of the rooms of the hotel have private baths, both tub and shower, and at rates of $2.50, $3.00 and $3.50 per day for single person. There are plenty of rooms at $2.50. The hotel provides very suitable accommodations for the technical meetings and the society has been promised the fullest co-operation of both the hotel management and the Moline chamber of commerce.

We would suggest that persons communicate directly with the hotel management for reservations at the time of the meeting, signifying the type of room and price they desire to pay. In making reservations, it is important that a second choice be given in the event that the first choice of room is not available.

The Tri City Spring Sectional meeting provides another op-

portunity for members to get together for the purpose of exchanging ideas and the renewal of acquaintanceship, and every member should make every possible effort to be present at this meeting.

Plans of the committees have progressed far enough so that they can assure us with the utmost confidence that the meeting will be highly interesting and profitable. Ask those who attended the Rochester Sectional meeting and judge for yourself the value and importance of these sectional meetings. May we urge your attendance.

WINTER SECTIONAL MEETING WELL ATTENDED

FOR those who were present at the Winter Sectional meeting held in Rochester, Jan. 31 and Feb. 1, there is little need to relate that this meeting was most successful and highly profitable, both from the technical and social viewpoint. More than 200 members of the American Society for Steel Treating hailing from 10 different states, were in attendance.

From the viewpoint of the number in attendance, the high standard and quality of technical papers presented, and the interesting and instructive plant visitation, this meeting surpasses all previous ones held by the Society. Much credit is due the members of the Rochester chapter for their very efficient and capable management of this meeting.

THURSDAY, JAN. 31

The Hotel Seneca was the official headquarters for the meeting and at 10 a. m. registration of members and guests took place. At 11 a. m. the first technical session was called to order by the chairman, E. F. Cone, associate editor of *Iron Age,* New York City.

After an address of welcome by J. J. Desmond, chairman of the Rochester chapter, A. H. d'Arcambal, chief metallurgist, Pratt & Whitney Co., Hartford, Conn., was introduced. Mr. d'Arcambal, who is well known to most of the members of the Society, presented a very interesting and instructive paper entitled, "Some Carbon and High-Speed Steels Used in the Manufacture of Small Tools." Mr. d'Arcambal touched briefly upon some of the salient features and methods employed in the manufacture of tool steel

and pointed out some of the common defects occurring in them. His paper was divided into two main parts in which he covered first, carbon tool steels and secondly, high-speed steels. He brought with him a large number of specimens of tools of various types and designs which exhibited both good and defective types of material. These specimens created much interest and brought forth a large amount of constructive discussion.

"Structure of Metals," by O. W. Ellis, assistant professor of metallurgy, University of Toronto, Toronto, Canada, was the title of the second and final paper on the morning session, which was presented in abstract form by R. T. Bayless, editor of TRANSACTIONS of the Society. This paper presented the author's colloidal theory as contrasted with the amorphous and other theories.

Dr. S. L. Hoyt, metallurgical engineer, research laboratory, General Electric Co., Schenectady, N. Y., and Dr. Zay Jeffries, research bureau, Aluminum Co. of America, Cleveland, discussed this paper, taking considerable exception to the author's colloidal theory and stating their preference for theories advanced by previous investigators.

Following a luncheon at noon, the afternoon program was opened by A. W. F. Green, metallurgist, John Illingworth Steel Co., Philadelphia, who presided as chairman. After a short address of welcome to Rochester by Mayor C. D. Van Zandt, the first speaker, Prof. H. M. Boylston, head of the department of metallurgy, Case School of Applied Science, Cleveland, was introduced. Professor Boylston's paper was entitled, "Control of Production by Scientific Methods." This address was of a general nature, illustrated by slides, and dealt with some of the modern methods of scientific control as applied to the production and heat treatment of steel. A brief discussion followed this paper pertaining to the routine of commercial use of X-ray analysis and some of the recent developments in magnetic examinations and in metallography, including unusually high power magnification and conical illumination.

The chairmanship of the meeting was then turned over to Dr. Walter M. Mitchell, Philadelphia, who introduced as the next speaker, Dr. Ancel St. John, of the Union Carbide and Carbon Research Laboratory, Long Island City, N. Y., who gave a very interesting address, entitled, "Recent Developments in X-ray Crys-

tal Analysis." The speaker illustrated his paper with various specimens showing the atomic construction of different crystals of the face-centered and body-centered orientation. In addition, Dr. St. John demonstrated by means of a small X-ray machine, the application of X-rays to the examination of iron, aluminum and other metals. He also discussed with the aid of lantern slides, the work done by Watertown arsenal, in perfecting its foundry practice by means of the X-ray examination of steel castings, and gave an explanation of the application of the X-ray to crystal analysis. Dr. St. John expressed the opinion, that he believed that at some time the X-ray will be not only a method of control in metallurgical operations, but will be available on a commercial scale for the examination of steel.

The third paper of the afternoon was read in abstract by J. V. Emmons, chief metallurgist, Cleveland Twist Drill Co., Cleveland, and was entitled, "The Annealing of Tool Steel." Mr. Emmons discussed in detail, some of the most important phases of this subject, dealing largely with carbon tool steel containing from 0.60 to 1.50 per cent carbon.

"The Photo-elastic Method of Stress Analysis" was the title of an illustrated paper given by A. J. Kimball, of the General Electric Co., research laboratory, Schenectady, N. Y. This paper was illustrated with autochrome color plates in which the color bandings due to passing polarized light through transparent replicas of gears and pinions were admirably portrayed.

G. R. Brophy, research laboratory, General Electric Co., Schenectady, N. Y., presented the final paper which was entitled, "Some Properties of Railway Motor Pinions." Mr. Brophy's paper, which was illustrated, demonstrated some of the predictions made in A. J. Kimball's paper, of photo-elastic analysis. It was shown that failures in certain railroad motor pinions occurred along lines showing the highest straining, as observed by the photo-elastic method of analysis when applied to celluloid replicas of the pinions.

An informal banquet was held on Thursday evening at the Rochester chamber of commerce. This was a joint meeting of the members of the American Society for Steel Treating and the Rochester chamber of commerce. S. M. Havens, national director of the Society and assistant treasurer and manager, Ingalls-Shepard Division, Wyman Gordon Co., Harvey, Ill., acted as toast-

master in the absence of Dr. Rush Rhees, president, University of Rochester, originally scheduled. There were brief addresses given by James E. Gleason, president, Gleason Works, Rochester, representing the chamber of commerce, and by Arthur S. Gale, professor of mathematics and dean of the University of Rochester. Dr. George K. Burgess, national president of the American Society for Steel Treating and director of the United States Bureau of Standards, Washington, was unable to be present to deliver his address. However, he sent his representative, R. M. Hudson, assistant chief of the Division of Simplified Practice, Washington, who read an interesting paper on the simplification and standardization work being done by the government and co-operating bodies. Mr. Hudson's paper is published in this issue of TRANSACTIONS.

FRIDAY, FEB. 1

No technical sessions were held on Friday, Feb. 1, the entire day being devoted to plant visitation. In the forenoon the visiting members were shown through the plants of the Gleason Works and the Taylor Instrument Co. At noon the Bausch and Lomb Optical Co. entertained the members at luncheon, and then conducted them on an inspection trip through their plant. The final trip of the afternoon was a visit to the research laboratories of the Eastman Kodak Co.

REPORT OF THE MEETING
of the
BOARD OF DIRECTORS OF THE AMERICAN SOCIETY FOR STEEL TREATING
Meeting Held at the
Hotel Seneca, Rochester, N. Y.
January 31, 1924, at 9:30 P. M.

All officers and directors were present except Dr. G. K. Burgess. In the absence of Dr. Burgess, Vice President W. S. Bidle presided

THE minutes of the meeting of the Board of Directors in Washington, Nov. 2, 1923, were approved without reading, inasmuch as copy of minutes had been forwarded to the members for approval.

The special research finding committee appointed at the

November meeting, consisting of H. J. French, chairman, and Messrs. Brophy and Merica, members, presented a report as follows:

Report of Research Finding Committee of the American Society for Steel Treating

A meeting was held in New York, Dec. 21, 1923, by the group appointed by the National Board, to investigate the field for a research committee in the American Society for Steel Treating. It was decided that such a research committee would fill a real need in the Society, and at the same time would constitute a valuable service of the Society to the metallurgical industries, providing a suitable mechanism is established to enable it to function properly. We therefore recommend that such a committee be organized and maintained by the National Board of Directors.

I. Field for the Committee

It is felt that the Research Committee should be a clearing house for the gathering, formulation, classification and distribution of research problems. It will not, however, be the function of the committee, under the proposed plan, to initiate, nor in general, to actively press agencies to carry out problems. If problems are accepted, the committee will follow the progress of the investigations and endeavor to secure credit for the Society for publication.

II. Organization of the Committee

It is suggested that the Research Committee consist of one member from each chapter in the Society, who should preferably also be chairman of any local research committee if such is maintained by a chapter. From this group there should be selected an Executive committee of three, which together with the paid secretary of the Recommended Practice Committee would be charged with formulation of the plans and policies to be followed by the main commmittee, as well as with other duties subsequently described.

III. Working Mechanism

Under the proposed plan the Research Committee might operate either as a sub-committee of the Recommended Practice Committee, or as an independent group working in close co-operation with it.

IV. Committee Meetings

The main committee would meet once each year during the Annual Convention of the Society with no expense to the Society, but funds for several meetings of the executive group should be provided.

V. Gathering of Problems

All problems will come through the local members of the Research Committee or directly to the paid Secretary of the Recommended

Practice Committee, who will also act as the Secretary of the Research Committee. He will then take steps to find out through the Recommended Practice Committee whether the answer is available or whether the problems should be placed on the master list of research problems for distribution.

VI. Formulation of Problems

It is desirable to have a local formulation of the problem, or in case of presentation directly to the paid secretary, formulation by him. But in any case, approval should be given by the executive group at one of their meetings before the problem is placed on the master list.

VII. Classification of Problems

Classification of problems according to facilities necessary, or on any other basis, will also be taken care of at meetings of the executive group.

VIII. Distribution of Problems

Maintenance of problem lists and their general distribution will be taken care of by the paid secretary. A principal feature of the distribution of this list will be semiannual publication in Transactions and distribution to a selected list of investigators.

When requests for research problems are received, copies of the master list can be forwarded by the paid secretary.

It shall be the function of the paid secretary to secure the closest possible relations between the proponents of any problem and the men working on it. But this should be done only with the knowledge and consent of the proponents in each case. Furthermore, the names of proponents will in no case be included on lists for distribution or publication.

IX. Further Comments

As a measure for obtaining permanency and continuity in this work, the principal correspondence should be issued from the headquarters of the Society and the files located there. Inasmuch as the operation of this plan will require a good deal of correspondence, its execution will necessitate part time services of the paid secretary of the Recommended Practice Committee.

It may be well to emphasize the fact that under the proposed plan, the Research Committee cannot serve as a clearing house for general information, but has a well defined field which cannot readily be handled by other existing agencies in the Society.

The scheme proposed is based on suggestions made by the first chairman of the Research Committee, Colonel A. E. White. It is similar to a plan recently instituted by the National Research Council in a broader field. Therefore, one of the functions of the Committee shall be close co-operation with this organization.

Upon motion properly made and seconded, it was unanimously carried that the report be accepted.

J. Fletcher Harper, chairman of the Recommended Prac-

tice Committee presented a report of the Sub-committee on Heat Treatment Definitions. This committee consists of R. M. Bird as chairman with the other members as listed in the TRANSACTIONS, and had presented a report to the Recommended Practice Committee at its meeting in Rochester on Jan. 31. The report of this Sub-committee on Heat Treatment Definitions, as approved by the Recomended Practice Committee, is as follows:

DEFINITIONS OF TERMS RELATING TO HEAT TREATMENT OPERATIONS TENTATIVELY APPROVED BY RECOMMENDED PRACTICE COMMITTEE— JANUARY 31, 1924

FOREWORD

1. During recent years, heat treatments have become more and more complicated and as a result there has arisen certain confusion in regard to the meaning of commonly used terms. For instance, in one locality or trade any operation of heating and cooling resulting in a softening of the material is being called annealing, whereas in other places to "anneal" means not primarily "to soften," but to heat to above the "critical temperature" and to cool very slowly. Similar confusion as to meaning and application exists in regard to other terms, and as a result "annealing," "tempering," "normalizing," etc., are being used by different people to mean widely different things.

2. In any attempt to accurately define the terms commonly used in connection with heat treatment, the first question to decide and the most important one is: do the terms relate to the heat treatment operation itself or to the results obtained by the treatment? In other words, is the term indicative of the structure or the condition obtained or of the operation performed?

3. After careful consideration, it appears most logical and most in keeping with present day usage to have the terms so defined that they shall mean definite operations and shall not be considered as referring to the structures or general conditions resulting, although, in a great majority of cases, the structures or conditions resulting may be quite similar.

4. At first glance, it would appear entirely unnecessary to coin any new words. It seems, however, that one of the reasons for the confusion that has come to exist is the lack of adequate terms with which to express the different operations and conditions met with. In suggesting the use of the term "loneal," an attempt is made to relieve the term "anneal" of some of the misuse which it suffers and to eliminate the term "draw" which has such wide application in regard to

the mechanical operations performed on metals as distinct from thermal treatments.

5. In commercial practice, the terms here defined will vary slightly depending upon the material under consideration. A "relatively slow rate of cooling" does not mean the same thing for an alloy steel as for a plain carbon steel, but the general meaning of the terms should remain the same regardless of material being treated. This must necessarily be the case if the term relates to the actual operation and not to the structure or the condition resulting from the operation.

6. Heatings and coolings, during any part of which steel is worked mechanically, are excluded from the meanings of the terms here given.

7. By "heating" as appearing below, is meant a thorough and uniform penetration of the heat.

8. By "critical temperature" as appearing below is meant that temperature which is customarily associated with the following phenomena:

(a) Hardening when quenched
(b) Loss of magnetism
(c) Absorption of heat
(d) Formation of solid solution
(e) Pronounced refinement of coarse grain upon cooling

HEAT TREATMENT DEFINITIONS

1. ANNEALING. Heating above the "critical temperature" followed by a relatively slow rate of cooling.

2. LONEAL. Heating below the "critical temperature" followed by any rate of cooling.

3. NORMALIZING. Heating above the "critical temperature" followed by an intermediate rate of cooling.

(Note)—In good practice, the heating is considerably above the "critical temperature."

4. SPHEROIDIZING. A long time heating at or about the "critical temperature" followed by slow cooling throughout the upper part of the cooling range.

(Note)—For the purpose of spheroidizing the cementite in high carbon steels.

5. HARDENING. Heating above the "critical temperature" followed by a relatively rapid rate of cooling.

6. TEMPERING. Reheating, after hardening, to some temperatures below the "critical temperature," followed by any rate of cooling.

7. CARBURIZING. Adding carbon, with or without other hardening elements, such as nitrogen, to wrought iron or steel by heating the metal below its melting point in contact with carbonaceous material.

8. CASE HARDENING. Carburizing the surface portion of an object and subsequently hardening by suitable heat treatment.

9. CYANIDING. A specific application of carburizing where the object, or a portion of it, is heated and brought into contact with cyanide salt.

Upon motion properly made and seconded, it was unanimously carried that the report of the Recommended Practice Committee on Heat Treatment Definitions be accepted. The Board requested the president to forward the report of this sub-committee to the various other technical societies and interested persons, as well as to the members of American Society for Steel Treating, for their reactions.

W. S. Bidle, chairman of the Convention Committee, presented a report giving the dates of the fifth annual convention as Sept. 22 to 26 inclusive, and the selection of Boston for the convention city. Upon motion properly made and carried, this report was accepted.

Consideration was then given to the advisability of publishing a year-book of the membership of the Society, and the cost of this was estimated at $1800. It was felt that inasmuch as the Year-Book would be of benefit to so few members of the Society, that the Directors were not justified in authorizing this heavy expenditure. Upon motion properly made and carried it was decided that no Year-Book would be published. The meeting then adjourned.

REPORT OF ADJOURNED MEETING
of the
BOARD OF DIRECTORS OF THE AMERICAN SOCIETY FOR STEEL TREATING
Meeting Held at the
Hotel Seneca, Rochester, N. Y.
February 1, 1924

All Officers and Directors were present except Dr. G. K. Burgess. In the absence of Dr. Burgess Vice President W. S. Bidle presided

The treasurer submitted an unaudited financial report for the year 1923. Upon motion properly made and seconded it was unanimously carried that the unaudited report be accepted. The report is as follows:

UNAUDITED ANNUAL PROFIT AND LOSS STATEMENT
AMERICAN SOCIETY FOR STEEL TREATING
January 1 to December 31, 1923

INCOME		
Dues (gross)	$30,598.03	
Transactions advertising	23,704.60	
Transactions sales	1,164.45	
Bindery account	484.25	
Reprints	746.45	
Discounts received	105.12	
Interest received	1,272.16	
Henry Marion Howe medal fund (interest received)	71.54	
Miscellaneous	201.33	
1923 convention	38,990.98	$97,338.91
EXPENSES		
Discounts allowed	60.37	
Bindery account	108.35	
Reprints	484.15	
Data sheets	927.63	
Library	257.28	
Henry Marion Howe medal fund	574.37	
Miscellaneous	434.53	
Transactions	21,931.62	
Secretary's office	9,104.40	
President's office	134.11	
Treasurer's office	1,655.13	
Directors' expense	2,072.10	
National committees	1,522.48	
Sectional meetings	775.99	
Increase of membership	322.20	
Dues refunded to local chapters	12,751.45	
Incidentals	44.29	
1923 convention*	28,007.49	81,167.94
Excess of income over expense before depreciation		$16,170.97

BALANCE SHEET

ASSETS				
Commercial account Cleveland Trust Co			$3,886.18	
Savings account Cleveland Trust Co			2,714.67	
Savings account Equity Savings and Loan Co			8,868.53	
Savings account Union Trust Co			1,082.42	
Bond investments			21,000.00	
United States treasury certificates			2,015.00	
Accounts receivable for advertising			2,137.24	
Accounts receivable miscellaneous			1,259.05	
Office furniture and fixtures			2,756.96	
1923 convention accounts receivable			1,219.22	
1924 convention prepaid expenses			436.16	
Prepaid expenses Rochester sectional meeting			54.35	
Inventory January 1, 1924			2,119.48	$49,549.26
LIABILITIES				
Accounts payable			$1,149.27	
Reserve for dues paid in advance			10,000.00	
Reserve for doubtful accounts			1,000.00	
Permanent convention reserve**			20,000.00	
Henry Marion Howe medal fund			3,000.00	
Surplus account		$3,229.02		
Excess income over expense in 1923	$16,170.97			
Less amount added to convention reserve**	10,000.00	6,170.97	14,399.99	49,549.26

*No commissions on convention receipts were paid to any employe or officer of the American Society for Steel Treating.

**Action taken by board of directors at meeting January 31 and February 1, 1924.

Depreciation of Office Furniture and Fixtures of $1,756.96, also authorized by Board of Directors, reduces profit for 1923 to $14,414.01; Surplus Account to $12,643.03 and Office Furniture and Fixtures Account to $1,000.00.

The treasurer then brought to the attention of the Board a number of recommendations made by the Finance Committee, consisting of Dr. Zay Jeffries, as chairman, and the other members as listed in TRANSACTIONS.

The Finance Committee recommended that bad accounts to the amount of $327.00 be written off and placed for collection, and this was approved.

The next recommendation of the Finance Committee was that the depreciation on office furniture be taken at $1756.96, leaving the value of the office furniture and fixtures on Dec. 31, 1923, at $1000. Upon motion properly made and seconded, it was carried, that the recommendation be accepted, and it was so ordered.

The Finance Committee further recommended that $10,000 of the Society's moneys now in savings accounts, be invested in government securities, and upon motion properly made, seconded and carried, it was decided to invest $10,000 of the Society's moneys at present in savings accounts in government securities, and that this $10,000 should be added to the permanent convention reserve fund.

The Finance Committee recommended, and the Board approved including the following inventory as an asset of the Society:

700 bound volumes, @ $2.00 each	$1400.00
Paper and cover stock, on hand	586.50
Howe Medal	132.98
Total	$2019.48

The Treasurer then presented a statement as to the time for the appearance of the financial statements of the Society, in order to comply with the direction of the Board that a financial statement of the condition of the Society should be published quarterly in the TRANSACTIONS. The suggestion was made and approved, that the first statement in 1924 should be the unaudited financial statement for the year 1923, the second report to be for the first three months of 1924, the third report for the first six months, the fourth report for the first nine months of the year, and the next report to be the unaudited financial statement for the year.

The budget as prepared by the Finance Committee was then presented for consideration and was adopted as follows:

BUDGET OF INCOME AND EXPENSE AMERICAN SOCIETY FOR STEEL TREATING AS PASSED BY BOARD OF DIRECTORS

Year of 1924

ANTICIPATED INCOME		
Dues (gross)	$33,000.00	
Transactions advertising	29,000.00	
Transactions sales	1,500.00	
Bindery account	700.00	
Discounts received	100.00	
Interest received	1,600.00	
Data sheets	900.00	
Miscellaneous	225.00	
1924 convention	22,000.00	$89,025.00
ANTICIPATED EXPENSE		
Discounts allowed	65.00	
Bindery account	900.00	
Reprints	100.00	
Data sheets	2,600.00	
Library	200.00	
Miscellaneous	56.00	
Transactions	25,650.00	
Secretary's office	9,995.00	
Treasurer's office	1,715.00	
President's office	200.00	
Directors' expenses	2,200.00	
National committees	5,500.00	
Sectional meetings	800.00	
Increase of membership	500.00	
Bad accounts	500.00	
Local chapters	13,500.00	
Incidentals	1,000.00	
Reserves	3,044.00	
1925 convention	500.00	
1924 convention	20,000.00	$89,025.00

Upon motion properly made and seconded it was carried, that the salary of the secretary should be made $7800.00 per year, effective Jan. 1, 1924.

Upon motion properly made and seconded it was carried that the salary of the editor of TRANSACTIONS should be made $4200.00 per year, effective Jan. 1, 1924.

The subject of Junior membership was then given consideration a request having been received for an interpretation by the Board of the meaning of the word "student" as used in stating the qualifications for a junior member. Upon motion properly made and seconded it was carried, that the interpretation given to that portion of the definition for qualification of Junior members as contained in Article IV, Section 1, F (1) shall be as follows:

> "An individual to qualify for Junior membership must have as his principal occupation, that of a student."

Upon motion properly made and carried the secretary was instructed to visit the Pacific Coast, in order to extend the activities of the Society. The meeting then adjourned at 11:45 a. m.

HEAT TREATMENT TERMS AND DEFINITIONS REFERRED TO TECHNICAL SOCIETIES

THE report of the Recommended Practice Committee on Heat Treatment Definitions as incorporated in this issue of TRANSACTIONS in the report of the Board of Directors' Meeting held in Rochester, Jan. 31 and Feb. 1, 1924, has been placed in the hands of the several American technical and engineering societies, the press, our members and other interested parties by our president, Dr. George K. Burgess. This action has been taken in order to secure the recommendations of the various societies and individuals, before these proposed definitions are adopted by the A. S. S. T. as a Tentative Recommended Practice.

It was the feeling of Dr. Burgess, the Board of Directors, and the subcommittee, that much publicity should be given these proposed definitions in order that constructive criticism may be obtained so that these definitions may comply with, and fit the needs of the entire industry, before being adopted as Tentative Recommended Practices of the A. S. S. T.

GETTING READY!

IT IS a characteristic of New Englanders, that when they have anything to do they begin to make plans immediately for carrying it to a successful conclusion.

Consequently, the executive committee of the Boston chapter has made its appointments of the chairmen of the various committees to handle convention details for the chapter during the Convention and Exposition, Sept. 22 to 26.

Mr. A. O. Fulton, vice president of the Wheelock-Lovejoy Co. has been appointed general chairman, and the chairmen of the various other committees are as follows:

MEETINGS AND PAPERS: L. D. Hawkridge; FINANCE: L. H. Wetherell; MEN'S ENTERTAINMENT: G. C. Davis; LADIES' ENTERTAINMENT: W. W. Cummings; INFORMATION AND RECEPTION: H. E. Handy; LOCAL EXHIBITS: L. E. Zurbach; TRANSPORTATION: Leslie Heath; REPRESENTATIVE OF BOARD OF DIRECTORS: F. P. Gilligan; MEMBER EX-OFFICIO: Chairman of Chapter.

The make up of this committee portends in advance a most competent and successful handling of the 1924 convention.

THE PHYSICAL PROPERTIES OF METALS AT ELEVATED TEMPERATURES

By V. T. Malcolm

Abstract

In this age of progress when designers of central power stations and oil refineries are vying with each other in the use of high temperatures and pressures, it has become a necessity for those interested in this class of work, to investigate their metals, so that a thorough knowledge of the materials to be used at elevated temperatures, will be available and their limitations known.

Specifications for this class of work now contain a clause regarding the testing of metals at elevated temperatures, and the framing of these specifications certainly depends upon antecedent knowledge of the behavior of the metals under those conditions to which they will be subjected to in service. Therefore, for this class of work, a careful study must be made of the characteristics of alloys, as failure is likely to be disastrous to both property and life.

Some few years ago, pressures exceeding 200 pounds and 400 degrees of temperature were unknown, but with the advent of better and more uniform materials, and the rapid strides in the metallurgical and manufacturing process, we are now using pressures of 450 pounds and 750 degrees of temperature and are contemplating the use of 1250 pounds pressure with 900 degrees of temperature.

Introduction

IN VIEW of the fact that most of the recent investigations of metals at elevated temperatures have to do with rolled or forged steel, it was important that an investigation be carried out for cast metals, on account of the increasing use of such metals for valves to withstand high pressures and elevated temperatures, which several years ago was looked upon with great doubt. Since then, service tests and research have proven that such metals as cast steel, Davis metal and monel metal will function satisfactorily at elevated

A paper presented before the fifth annual convention of the Society, Pittsburgh, Oct. 8-12, 1923. The author, Vincent T. Malcolm, is metallurgist with the Chapman Valve Mfg. Co., Indian Orchard, Mass.

temperatures and high pressures. There is, to the authors knowledge, quite a number of installations operating in oil refineries at 500 pounds pressure and at 800 degrees Fahr., having valves handling vaporized oil. These installations have been in service several years and are today in splendid condition.

Many processes require the use of metals at elevated temperatures, and in this class of work the degree of success of an alloy or metal, is measured by its stability under such working conditions. As a matter of fact, most failures at elevated temperatures are not due to the quality of the alloy, but to the improper application of certain metals when used in connection with the work for which they are entirely unsuited. For high pressures and elevated temperatures a careful study must be made of an alloy's characteristics, etc., as failure is likely to be disastrous to both property and life.

A large amount of research work has been carried out by the writer in recent investigations into the effect of elevated temperatures on metals used in the construction of valves, as most of the previous data have been crude, and results obtained not consistent with the present day experiments.

A most extensive series of tests were made on iron and steel at the Watertown Arsenal (Tests of Metals, etc., 1888). As this was before the day of electric furnaces and thermoelectric pyrometers, the specimens were heated by a series of bunsen gas burners and the temperatures estimated from the coefficient of expansion of the heated specimen, using no temperature correction for the coefficient of expansion.

In 1890, Martens[1] published investigations on the tensile properties of iron, steel and copper at elevated temperatures.

He used a bath of paraffin for temperatures up to 200 degrees Cent. and a bath of lead or lead-tin alloy for temperatures from 200 degrees to 600 degrees Cent. For measuring temperatures he used, in the former case, a mercury thermometer and, in the latter case, an air thermometer.

In 1899, Unwin[2] published results which he obtained. The specimens were heated in an oil bath by a gas burner, and placed

1. Mittel unger aus den Tenchniche. Versuchs anst zu Berlin, 1890, page 159.
2. Report of British Association, 1899.

between the jaws of a special horizontal testing machine. The temperature was measured by means of a mercury thermometer.

Bregowsky and Spring[3] made an extensive investigation of the tensile properties of materials at elevated temperatures. Their method of heating the specimen was crude as was also the method of locating the thermocouple. The specimen was wrapped with asbestos and then a coil of resistance wire. The thermocouple was inserted into a hole bored through the end, extending to a point somewhat above the fillet at the end of the gage-length.

McPherran[4] also made a survey of the properties of materials at elevated temperatures. His equipment was practically the same as the equipment used in the present tests, but his thermocouple was much heavier (No. 8 wire) and introduced through the end of furnace, the thermo-junction being at the mid-point of the pull section. The yield point was determined by the drop of beam and not by extensometers.

In the discussion of McPherran's paper, Spooner describes high temperature tensile tests made on several materials. His furnace was approximately of the same design as McPherran's only it was two inches longer. The thermocouple was used in the same manner.

D'Arcambal[5] made tests on high speed steel, which were conducted with an apparatus similar to that of McPherran.

French[6], of the bureau of standards, has done considerable work of this nature. His furnace is of the same design as the foregoing, but his pyrometer fire-end is inserted into a small hole drilled just above the fillet on the test specimen.

With the above described work before us, it was decided to conform to the general design of McPherran's furnace, but to use a much finer thermocouple (No. 22 gage) in order to obtain greater sensitivity and to introduce it through a hole in the middle of the furnace. The results of these tests on steel were published[7] in 1922.

In January 1923 Priester & Harder[8] published an article on the effect of temperature on the mechanical and microscopic prop-

3. International Association of Testing Materials, 1912, Vol. VII.
4. American Society for Testing Materials, *Proceedings*, 1921, p. 852.
5. American Society for Steel Treating, TRANSACTIONS, 1922, Vol. II, p. 586.
6. American Institute of Mining Engineers. LXVII, p. 82. Bureau of Standards Technical paper No 219
7. Malcolm—TRANSACTIONS, American Society of Mechanical Engineers, 1922.
8. *Chemical and Metallurgical Engineering*, Vol. 28, No. 3, 1923.

erties of steel. The apparatus was similar to the equipment used in the present experimental work, except the thermocouple was located on the bottom fillet of test piece.

Object of This Investigation

This investigation was undertaken with the view of showing the characteristic physical properties of materials used in the construction of valves, as disclosed by the results of tensile tests

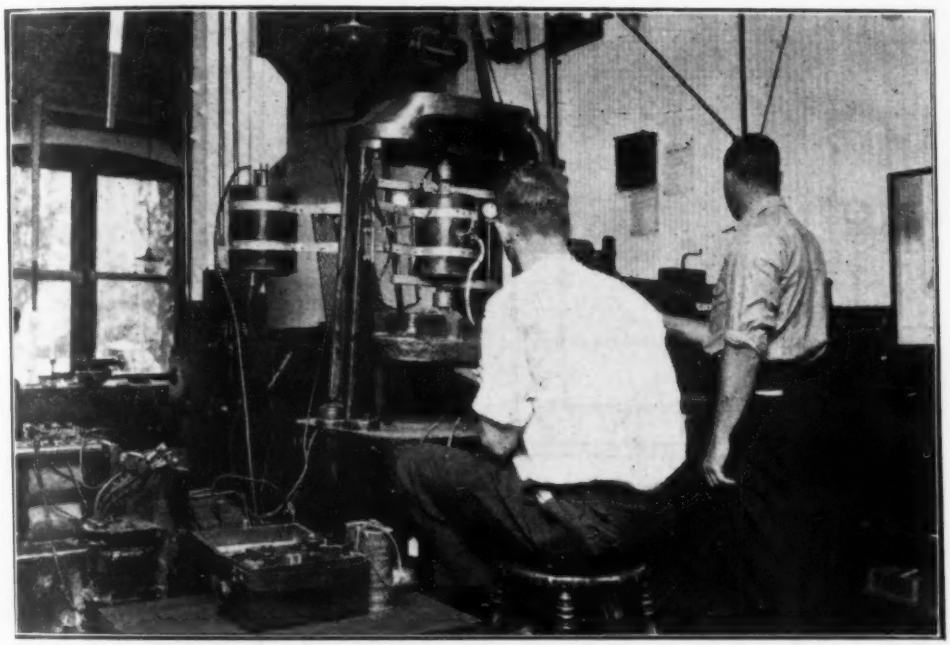


Fig. 1—Showing general arrangement of testing apparatus mounted on a universal testing machine.

conducted at a series of elevated temperatures. The results obtained may be expected to serve as a criterion of the physical properties available in the several materials when used in valves under conditions of superheat and also the relative values for such use.

Equipment Used

The tensile tests were made on the standard universal testing machine of 100,000 pounds capacity. The pyrometer equipment consisted of a portable indicating potentiometer and thermocouple of 0.025 inch alumel and chromel wire (22 gage).

Furnace

The furnace equipment was made in duplicate in order to facilitate the heating and testing of specimens. The furnaces were attached to the outer leg of the testing machine by hinges so that they could be swung alternately into place between the heads,

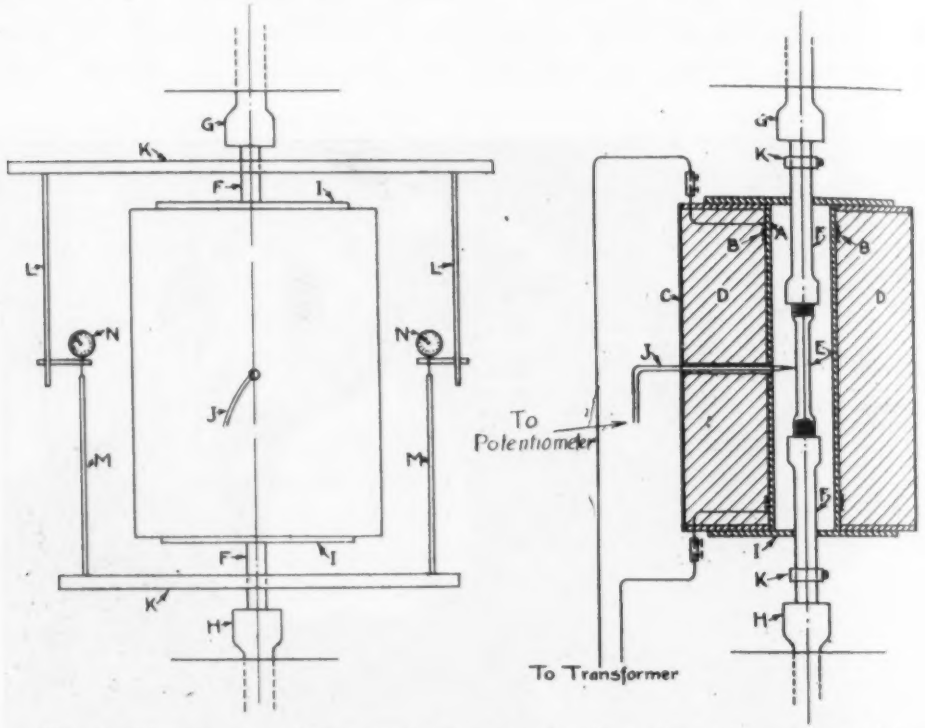


Fig. 2—Diagram of a furnace and set-up for tensile testing bars at elevated temperatures. "A" is an alundum tube upon which is wound the heating element "B". This heating element is connected to the secondary of a transformer. The tube "A" is held in the container "C" and the space between "D" is filled with kieselguhr. The specimen under test, "E", screws into the specimen holders "F", which in turn is screwed into the testing machine adaptors "G" and "H". "G" is the fixed member and "H" the moving member. When the specimen is in position, the doors "I" are closed and the thermocouple "J" placed against the test specimen at its mid-point. The doors "I" are made of asbestos board and fit snugly around the holders "F", so that no air currents can get into the heating chamber. As a further precaution against air currents, asbestos rope is wound around the holders "F" just outside the doors "I". The thermocouple is made of 0.025-inch diameter alumel chromel wire and is used with a potentiomenter. Arms "K" are rigidly fastened to specimen holders "F". The rods "L" are fastened to the upper arm "K", and rods "M" to the lower arm "K". Ames gages are connected to the fixed rods "L", and rest on the moving rods "M".

for test. Fig. 1 shows the general arrangement of apparatus and Fig. 2 a section of the furnace with specimen in place, and with the extensometer gages attached, and pyrometer inserted.

Test Bars

All of the test bars were cast in the foundries from regular heats of their respective metals, in the standard test block, as in

use daily in the foundry. They were then machined to the form of the two inch standard threaded end tensile bars as shown in Fig. 3. In addition to the above specimens for tensile tests, we used a special bar for the calibration test for each of the various metals tested as well as for certain temperature explorations and calibrations of the furnace. This bar is illustrated in Fig. 4.

Tensile Tests At Elevated Temperatures

In Fig. 2 "A" is an alundum tube upon which is wound the heating element "B". This heating element is connected to the

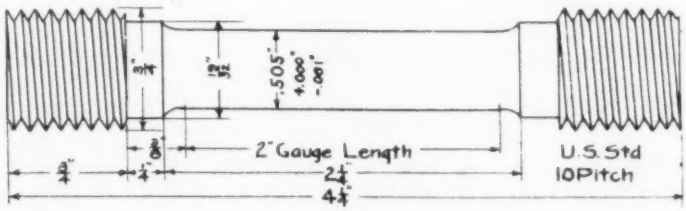


Fig. 3—Sketch of a tensile testing specimen used in making these tests.

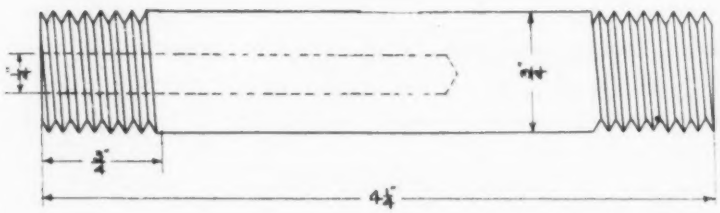


Fig. 4—Sketch of temperature calibration specimen.

secondary of a transformer. The tube "A" is held in the container "C" and the space between "D" is filled with kieselguhr. The specimen under test, "E", screws into the specimen holders "F", which in turn is screwed into the testing machine adaptors "G" and "H". "G" is the fixed member and "H" the moving member. When the specimen is in position, the doors "I" are closed and the thermocouple "J" placed against the test specimen at its mid-point. The doors "I" are made of asbestos board and fit snugly around the holders "F", so that no air currents can get into the heating chamber. As a further precaution against air currents, asbestos rope is wound around the holders "F" just inside the doors

"I". The thermocouple is made of 0.025-inch diameter alumel chromel wire and is used with a potentiometer. Arms "K" are rigidly fastened to specimen holders "F". The rods "L" are fastened to the upper arm "K", and rods "M" to the lower arm

Table I

Average Results of Physical Tests of Davis Metal

Temperature Degrees Fahr.	El. Limit Lbs. sq. in.	Max. Strength Lbs. sq. in.	Red. of Area %	Elon. in 2"—%
70	39300	65950	15.0	18.0
400	37100	56650	10.0	10.5
600	36150	55700	10.5	12.0
800	35800	52650	14.2	16.5
1000	35400	50300	18.0	20.0

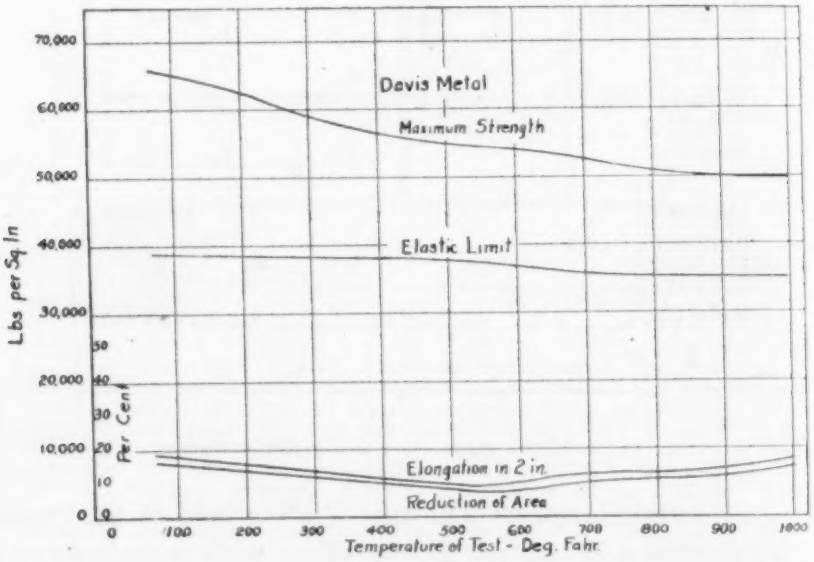


Fig. 5—Physical property curves of Davis metal tested at elevated temperatures.

"K". Ames gages are connected to the fixed rods "L", and rest on the moving rods "M".

Method of Test

The test specimen is inserted in the heating unit and testing fixtures described. After the specimen has been at heat at least one hour, an initial load of 100 pounds is applied in order to

eliminate all lost motion. The Ames gages are then set at zero, after which equal increments of load are applied and simultaneous readings of gages recorded. The size of the increment applied depends upon the kind of material under test and varied from 100 to 500 pounds. Observations of elongation per increment are recorded until the yield point is passed. The maximum strength,

Table II

Average Results of Physical Tests of Davis Metal Containing 2.5 Per Cent Lead

Temperature Degrees Fahr.	El. Limit Lbs. sq. in.	Max. Strength Lbs. sq. in.	Red. of Area %	Elon. in 2"—%
70	18500	57850	30.0	30.0
400	17150	48225	24.2	26.0
600	15125	39700	15.0	18.75
800	17125	29200	9.0	10.25
1000	16250	25600	7.5	8.2

per cent of elongation and per cent reduction of area are determined in the usual manner.

The Johnsonian elastic limit is determined from a curve drawn through the points obtained by plotting the elongation per increment of load.

Results of Test

Six groups of alloys were tested and the results are given in the following sections.

Davis Metal

The average results of physical tests on Davis metal at elevated temperatures are shown in Table I and Fig. 5. The results at elevated temperatures parallel those observed in normal material and corroborate the observations of service tests on this metal. The possibilities of this alloy aside from its noncorrosive properties are indicated by the excellent values obtained and the fine grain of metal noted.

It has long been known that any metal containing a medium percentage of lead is not fit for use in power plant work, so it was decided to verify these results. Therefore, an alloy was made

up of typically the same analysis as the Davis metal, but to which 2.5 per cent of lead was added, with the results as shown in Table II and Fig. 6.

From the results obtained this statement has been verified, i. e., that no alloy entering into power plant work, for superheated steam, should contain lead in any appreciable quantity.

Monel Metal

The monel metal used in test was made in our foundry from pure monel metal shot, and the test bars showed the following typical analysis:

	Per cent
Copper	29.48
Lead	none
Iron	2.36
Nickel	66.63
Manganese	0.98
Carbon	0.15
Silicon	0.40

The results at elevated temperatures parallel those observed in normal material and corroborate the observations of service tests

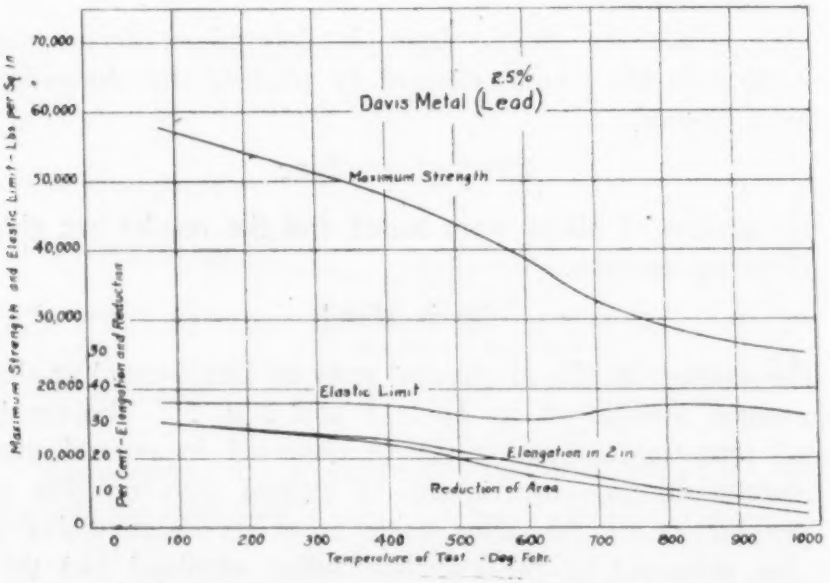


Fig. 6—Physical property curves of Davis metal containing 25 per cent lead tested at elevated temperatures.

on this metal. The average results of physical tests are shown in Table III and Fig. 7.

Cast Bronze (Steam Metal)

According to our observations bronze should never be used in connection with superheated steam. The average results of physical tests are shown in Table IV and Fig. 8.

The elastic limit appears to be the least affected by elevations of

Table III

Average Results of Physical Tests of Monel Metal

Temperature Degrees Fahr.	El. Limit Lbs. sq. in.	Max. Strength Lbs. sq. in.	Red. of Area %	Elon. in 2"—%
70	31650	63100	25.4	22.0
400	28833	53916	17.3	19.8
600	25813	53020	23.4	27.0
800	25943	52490	23.5	27.5
1000	25560	49580	23.9	27.6

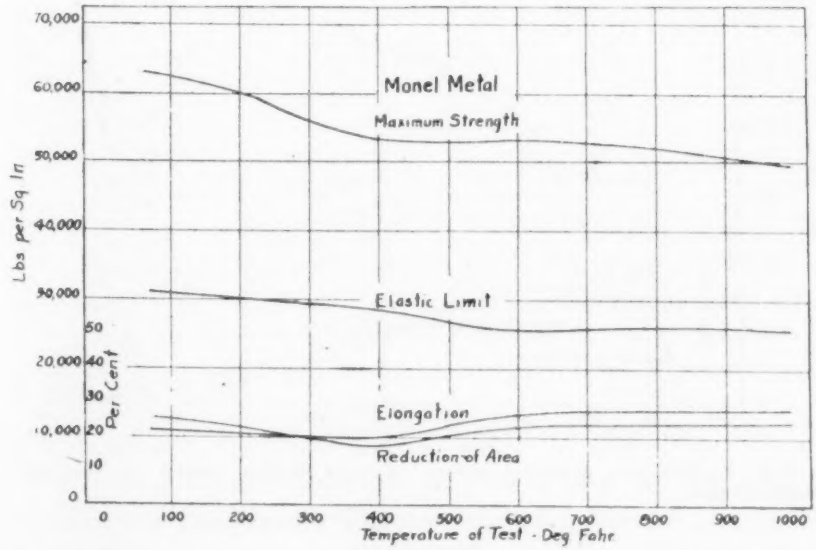


Fig. 7—Physical property curves of monel metal tested at elevated temperatures.

temperature, whereas the tensile strength, elongation and reduction fall sharply with elevations beyond 400 degrees Fahr.

This indicates an increasing brittleness, and a treacherous metal beyond 400 degrees Fahr., and corroborates service observations. It is also a reason why bronze cannot be used in valve trimmings in power plants using superheated steam.

Cast Steel

This steel was made by the acid electric process, and was subjected to the following heat treatment.

(1). Heated to 1650 degrees Fahr. and held two hours.
(2). Cooled in furnace to 1300 degrees Fahr.
(3). Then cooled in air to atmospheric.

The analysis of this steel was:

	Per cent
Carbon	0.254
Manganese	0.67
Silicon	0.31
Phosphorus	0.038
Sulphur	0.047

The specimens tested at room temperature show very good

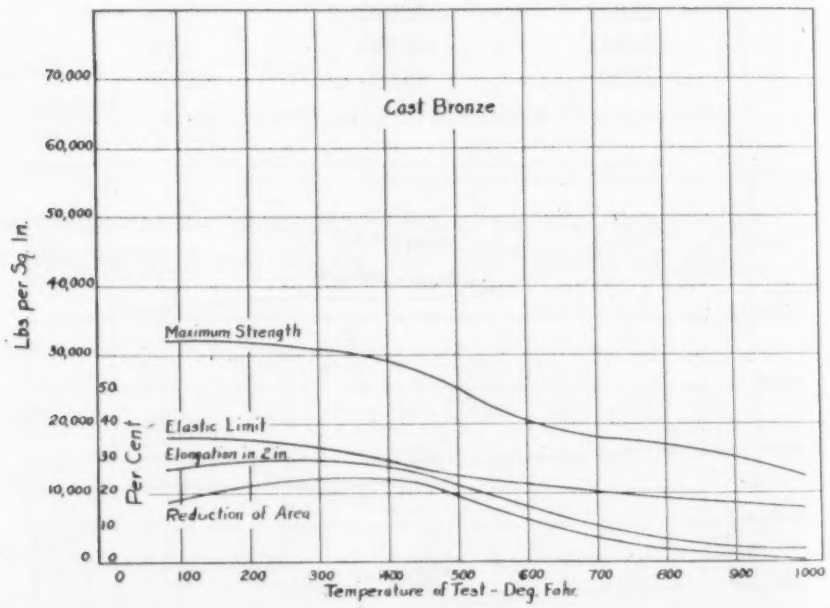


Fig. 8—Physical property curves of cast bronze tested at elevated temperatures.

Table IV
Average Results of Physical Tests of Cast Bronze (Steam Metal)

Temperature Degrees Fahr.	El. Limit Lbs. sq. in.	Max. Strength Lbs. sq. in.	Red. of Area %	Elon. in 2"—%
70	19800	32000	18.5	25.5
400	18360	29233	22.8	26.5
600	13100	23100	16.1	15.6
800	10700	17150	4.3	7.5
1000	8700	12641	1.0	2.3

Table V

Average Results of Physical Tests of Cast Steel

Temperature Degrees Fahr.	El. Limit Lbs. sq. in.	Max. Strength Lbs. sq. in.	Red. of Area %	Elon. in 2"—%
70	43000	75850	29.0	24.0
400	35166	67800	30.0	24.5
600	28116	67166	28.8	21.3
800	23000	70533	23.3	18.6
1000	20833	52466	53.6	28.8

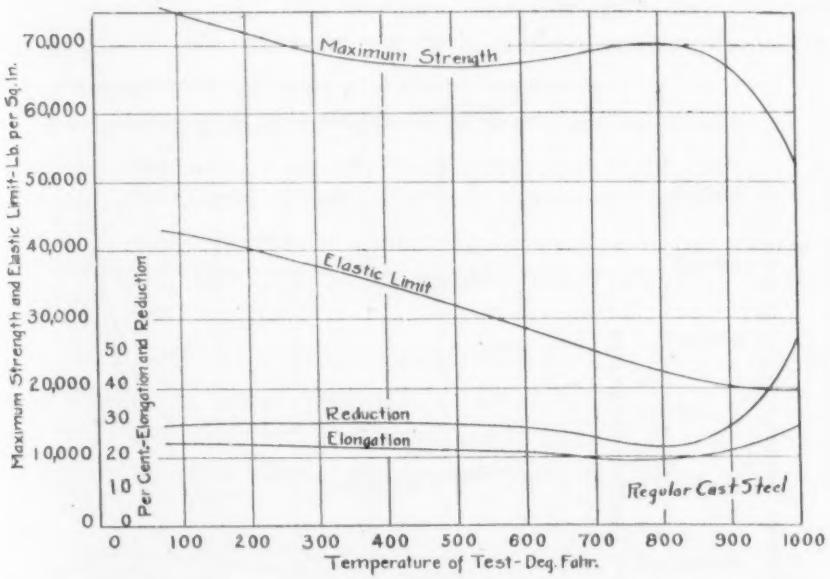


Fig. 9—Physical property curves of cast steel tested at elevated temperatures.

physical qualities for cast steel, (Table V and Fig. 9) and the summary shows a steady decline in elastic limit as the temperature is elevated to 1000 degrees Fahr.

The elongation and reduction show minor changes until 800 degrees Fahr. is reached, beyond which temperature they rise rapidly and indicate the absence of brittle and treacherous material. The tensile strength exhibits the usual early decline followed by an appreciable rise in the vicinity of 600 to 800 degrees Fahr. Above 800 degrees Fahr. the drop is sharp. The results obtained are normal of good quality cast steel (see TRANSACTIONS A. S. M. E. 1922 Vol. Discussion of steel at High Temperatures, V. T. Malcolm).

Alloy Steel

This material is used for bolts in valves and is rolled stock of the following chemical composition.

	Per cent
Carbon	0.55
Manganese	1.25
Silicon	0.19
Phosphorus	0.016
Sulphur	0.037
Nickel	0.050
Chromium	0.45

The average physical properties of this material is shown in Table VI and Fig. 10.

It is therefore evident that we have in this material a steel

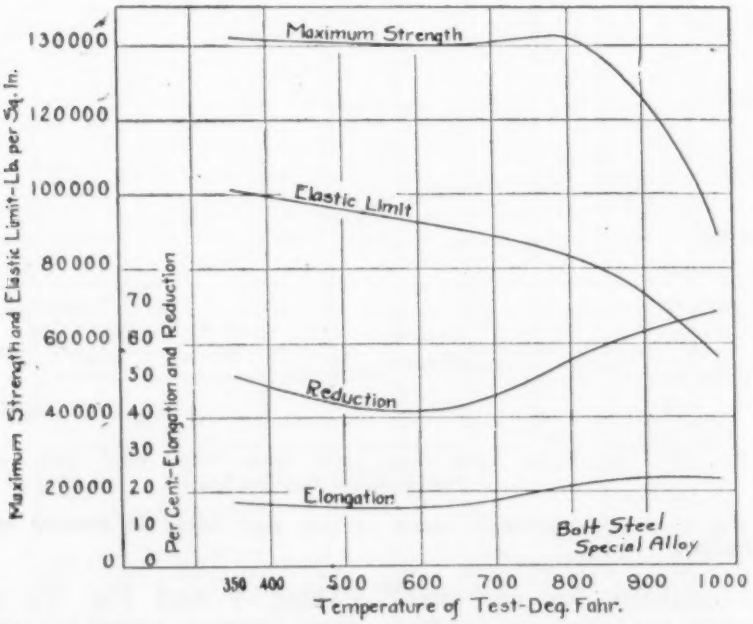


Fig. 10—Physical property curves of special alloy bolt steel tested at elevated temperatures.

Table VI

Average Results of Physical Tests of Alloy Steel

Temperature Degrees Fahr.	El. Limit Lbs. sq. in.	Max. Strength Lbs. sq. in.	Red. of Area %	Elon. in 2"—%
70	110000	145000	49.0	20.0
400	99000	131150	48.3	16.3
600	91750	129833	40.3	15.8
800	82830	131750	55.1	21.8
1000	56000	89000	67.6	22.6

which has solved the difficult problems of bolting for steel valves in connection with superheated steam at high pressures and temperatures.

This steel is heat treated at 1475 degrees Fahr. and quenched in oil after which it is drawn at 1200 degrees.

Conclusions Reached From Tests

The accuracy of the results depends primarily upon (1), the rate at which the load is applied; (2) the length of time the specimen is held under load at a given temperature; (3) the accuracy of the thermocouple, and (4) the true temperature of the material under test.

These points will be considered in order.

1. In general it may be said that the faster the rate of load application the higher the tensile properties. In these tests a slow rate was used in order to observe the deformations which were plotted to determine the elastic limit. In this respect, the values reported are on the low side as compared with values at ordinary testing speeds.

2. The tensile properties decreased with the length of time the specimen is held under load at a given temperature. This question may be dismissed from consideration inasmuch as all specimens were tested in approximately the same length of time, which was short.

3. In order to determine the accuracy of the thermocouples, the following procedure was used:

One of the thermocouples used was checked against a standard and was found to be correct within experimental error. All other thermocouples used were then checked against this one and found to be within the limits of experimental error.

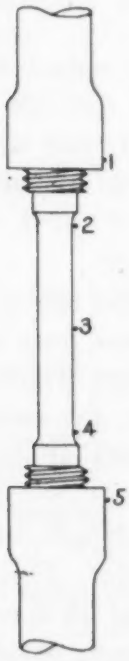
4. The third point, regarding the true temperature of the bar appears simple on its face but after some of its phases are uncovered it is found to be very complex.

The temperature of the specimen itself may vary in two ways (a) from point to point along the surface, and (b) from surface to center.

(a) The variation in temperature along the surface is easily determined by fastening the thermocouples to the points whose temperature is desired. In this test the temperature of three points

along the surface of the pull section of the specimen were determined, viz.: at the top fillet, at the midpoint, and at the bottom fillet. The results are shown in Fig. 11.

Although these differences are greater than those reported by French, in Technological Paper No. 219 of the United States



FURNACE EXPLORATION

Temperatures at Positions Indicated Deg. Fahr.					Differences in Temp. at Positions Indicated from That at 3-Deg. Fahr.				
1	2	3	4	5	1	2	3	4	5
295	330	365	308	273	-70	-35	0	-57	-92
508	547	600	521	477	-92	-53	0	-79	-123
677	738	791	717	636	-114	-53	0	-74	-155
877	938	991	921	832	-114	-53	0	-70	-159

Fig. 11—Diagram of tensile test specimens showing location of thermocouple in making various temperature exploration tests. The accompanying table shows the temperatures observed.

Bureau of Standards, we feel that they are as small as it is practical to make them under present circumstances.

(b) In order to determine the difference in temperatures between surface and center of the specimen, we used a set of bars (which will be designated hereafter as the calibration specimens) ¾-inch outside diameter with a ¼-inch hole bored from one end to ½ inch beyond the center. This gave a wall thickness of ¼ inch, equivalent to one-half the diameter of the standard ½-inch bar.

A thermocouple was placed against the outside, as was done on the regular tests, and another couple inserted in the longitudinal hole, both registering the temperature at the same section with ¼ inch of metal between. The whole apparatus was placed in the testing machine under the same conditions that obtained during

the regular tests and comparative observations made from room temperature to 1000 degrees Fahr. The temperature differences observed on the several materials tested were plotted as shown by the Fig. 12.

One of the specimens was then suspended in the furnace by means of a wire, with grips removed, the thermocouples being in the same relative positions, and the temperature observations dupli-

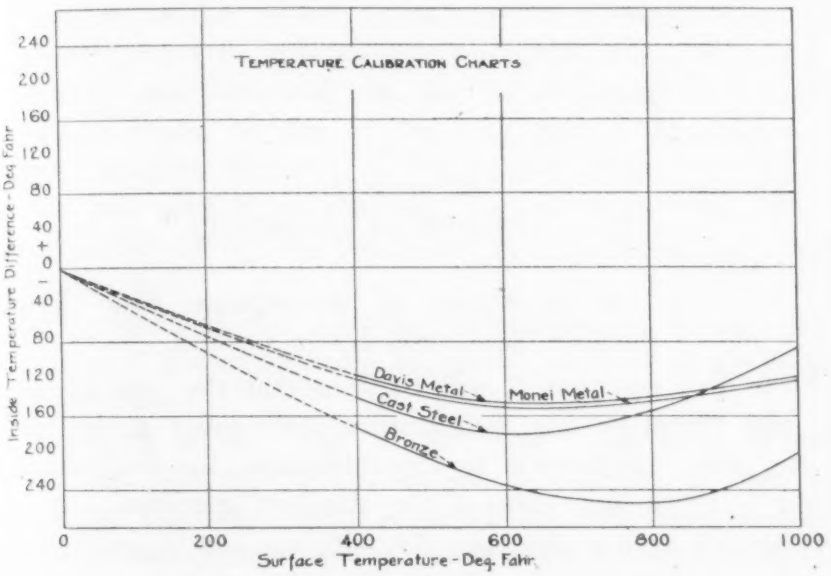


Fig. 12—Temperature calibration curves for Davis metal, monel metal, cast steel and bronze.

cated. The thermocouple readings with this set-up, coincided within the limits of experimental error which indicates that the difference in temperatures between surface and center is due to the loss of heat by conduction to adapters, holders, extensometer arms, etc.

Although the apparent difference in temperature is indicated to be 146 degrees Fahr., as the maximum at 600 degrees Fahr. for Davis metal and 254 degrees Fahr. as a maximum at 800 degrees Fahr. for bronze, with the calibration bar used this apparent difference exceeds appreciably, the true difference existing between the surface and the center of the standard ½-inch specimen. The reasons therefore are as follows:

1. When these differences are considered in connection with the temperature differences noted along the surface, the existence

of isothermals along the specimen must be assumed, which does not seem warranted.

2. The rate of heat transfer along a bar which is not at uniform temperature may be represented by the following equation:

$$\frac{dH}{dt} = \pi r^2 K \frac{(dT)}{(dl)}$$

Where $\frac{dH}{dt}$ = rate of flow of heat

πR^2 = area

K = coefficient of conductivity

$\frac{dT}{dl}$ = rate of change of temperature with change in distance from the hotter portion.

From this equation it will be seen that the rate of flow of heat; and therefore the temperature difference; varies directly with the area. Reference to the calibration bar will show that the area is twice the area of the standard specimen.

Inasmuch as the area was the only varying quantity between the two equations for standard and calibration bars, it is apparent that from this correction alone the temperature difference between surface and center would be reduced very materially below the apparent differences shown.

Assuming that there is a temperature gradient between points on the surface of the standard test bar and the center of a section through any of these points, the temperature measured at the surface would approximate more closely the mean effective temperature. This mean effective temperature would lie at the point of mean effective area, namely, one-third the distance in from the surface of the bar. This is the view set forth by McPherran in his answer to the discussion of his paper. For this reason, the temperature as registered by a thermocouple placed against the mid-point of the specimen was used as the temperature of the specimens in this investigation.

Referring particularly to variations in temperature along the length of the pull section of the standard test bar, observations

of the manner in which the bars broke under load cast considerable doubt on the possibility of there being any appreciable difference in temperature. It was observed that some of the bars broke close to top and bottom fillet and others at the center of the gage length. If there were a temperature gradient along the length from the center of the bar to the fillet, it would be natural to suppose that the center would be the weakest point in all cases, and that the majority of fractures would take place at this point, as the highest temperature is obtained here. However, as stated before, this was not observed to be the case.

Considering, therefore, all the experimental and theoretical observations made, we are of the opinion that the effective temperatures, whether they be in the center of the bar or at the ends, do not vary more than 40 degrees Fahr. from the temperature indicated by the pyrometer and in some cases may be considerably less.

As a result of the foregoing considerations (I-IV) we feel that the data presented may be safely used as a guide in the design of valves.

Therefore in the body of this report we have endeavored to show the materials available for high pressure, high superheat and the exacting manner in which the tests have been carried out, and in presenting this report we hope to have opened up a field in the United States, in which very little work has been done, and in which continental Europe has made rapid strides.

In closing, the author especially wishes to express his appreciation to his assistant, Mr. J. W. Juppenlatz, to Dr. E. C. Gilbert, Mr. E. O. Davis and Mr. F. P. Gilligan, for criticism and advice and to Miss B. Latourneau for her work in transcribing the notes, and it is hoped that this investigation will prove of interest and value to engineers, to whose judgment he submits.

Discussion of Mr. Malcolm's Paper

CHAIRMAN P. D. MERICA: Gentlemen, Mr. Malcolm's paper is before you for discussion. We will devote five minutes to it.

J. M. LESSELLS: It has been very interesting to listen to this paper. The thing that interested me most was the variation in temperature along the length of the specimen. I noted that in some cases it amounted to as much as 10 per cent. I do not believe that by measur-

ing the temperature of the test specimen at the point of rupture, that we can infer that the temperature of the gage length of the specimen is uniform through its length, because the effect of the fillet surely must be appreciable. Using the standard A. S. T. M. specimen, there is a very small fillet at the neck, and at high temperatures the effect of this fillet may be greater than even at normal temperatures. So I would like to ask the speaker if, before he commenced his work, he made any calibration temperature tests. I think a variation of 10 per cent in the temperature is too much.

I might mention that quite recently, a German publication has come into my hands, describing a similar test, wherein a gas furnace was used for heating the specimen. The total variation in temperature over a length of 4 inches was no more than 1.5 per cent. It is possible that more uniform heating could be obtained through the use of such a gas-fired furnace.

V. T. MALCOLM: I would answer your question by saying that we explored the furnace very thoroughly, and found very little difference in the temperature of the furnace at any point. At the top of the furnace we put asbestos hinged doors so as to be absolutely certain that we retain as much heat in the furnace as possible without radiating it to any other point. I will say that we are at the present time at work on more of these tests in which we intend to entirely change the test bar and use a furnace 50 per cent longer than the furnace we had here, also with a longer test bar, so we can explore further into the conditions.

W. J. MERTEN: I would like to ask Mr. Malcolm whether or not he has investigated the influence of differences in the structural condition of the steel as they affect the values obtained at high temperatures?

V. T. MALCOLM: We have investigated through the aid of a microscope, the effect of the temperatures on cast steel, on monel metal, Davis metal, and bronze. At the 1000 degree Fahr. temperature on cast steel, Davis metal, and monel metal, we found very little change in the structural composition. However, on cast bronze we did observe a change which was due, probably to a diffusion of the tin and lead in the cast bronze.

W. J. MERTEN: I believe that I did not make my question clear. I referred to the structural condition prior to heating the material.

V. T. MALCOLM: Yes, we investigated them prior to making the tests. The heat treatment on the steel casting prior to testing, was 1650 degrees Fahr., held for approximately two hours, dropped to 1300 degrees Fahr., and cooled in the air. The heat treatment given the alloy steel was 1475 degrees Fahr., quenched in oil and drawn back at 1200 degrees Fahr.

DR. GEORGE K. BURGESS: I would like to make one gen-

eral remark on this question of temperature measurement and distribution of temperature in furnaces. I noticed from this paper, and also from the discussion of Mr. French's paper, that there was apparently some doubt in the minds of some of the people present, as to the certainty at which the supposed conditions were attained. It seems to me that this is a field in which our Committee on Recommended Practice could do some work by outlining, for a given size of specimen, a given temperature, and a given atmosphere or bath, the conditions essential for the experimenter to fulfill in order that his experiments may be standard.

So much of the work that is done, is along lines in which we say that a piece of steel attains a certain temperature in a certain time, but I frankly think we do not yet know all of the contributing conditions sufficiently well so that a new experimenter going to work on a new problem involving this subject, will be perfectly sure that he is attaining those conditions.

I, therefore, think it would be wise for a committee or a group in connection with the Committee on Recommended Practice, to take this matter very seriously into consideration.

V. T. MALCOLM: I am pleased to hear you make that remark, Dr. Burgess. I certainly would like to see something done along these lines. Of course the work that Mr. McPherran, Mr. French, and myself, together with Mr. Gilligan, have done on this experimental work, is almost the same. We have used practically the same type of equipment and conditions. We have changed only minor details.

CHAIRMAN P. D. MERICA: I think it is quite in order that a notice of the suggestion which Dr. Burgess has made, be transmitted to the Committee on Recommended Practice. I presume that Mr. Bayless will take care of that.

SIMPLIFICATION AND STANDARDIZATION

By R. M. Hudson

Abstract

This paper reviews in a general way, the work that is being accomplished by the Division of Simplified Practice, Department of Commerce, together with many associations, societies and individual producers, in bringing about the standardization of materials produced, as well as effecting a reduction in the number of types, grades, brands, finishes and sizes. Much progress has been made in this work as is brought out by the author.

Introduction

THERE is not much difference between simplification and standardization, so far as the final results of their application are concerned; but there is a very noticeable difference in the processes of their application to our present great problems of eliminating waste in industry, conserving our material and our human resources, while increasing production and lowering our cost of living. Suppose we first consider simplification. This means the reduction of superfluous and unnecessary variety in sizes and dimensions of commonly used commodities. You may wonder why in these days, when "variety is the spice of life," there should be any suggestion that variety be reduced. But by way of illustration, the National Retail Hardware Dealers' association found through a survey, that the single bit axe—the common garden variety of axe that taught so many of us the meaning of labor—was made in 34 types, 4 grades, 35 brands, 11 finishes and 19 sizes.

A review of catalogs showed 6118 styles, patterns, models and sizes of the single bit axe listed by 3 different manufacturers. But you know that under the common sales philosophy, "You must give the buyer what he wants." So if you really insist, you can get any one of the 34 models, in any one of the 4 grades, the

A paper presented before the joint meeting of the members of the American Society for Steel Treating and the Rochester Chamber of Commerce, Thursday evening, January 31, 1924, Rochester, N. Y. The author, Ray M. Hudson, is assistant chief, Division of Simplified Practice, Department of Commerce, Washington, D. C.

35 brands, the 11 finishes, and the 19 sizes; or, in other words, take your choice from nearly a million possible varieties or combinations.

Too Many Models in Many Branches of Industry

This same diversity exists in many other lines—sink traps used in household plumbing are made in 714 different styles and sizes; piston rings for automobile engines in over 8000 varieties; and even the American flag is made in 289 different sizes, embracing 9 different proportions of length to width, and so on.

Emerson said, "If a man write a better book, preach a better sermon, or build a better mouse-trap, the world will beat a pathway to his door." What Emerson neglected to add, is that half of those who make the journey will go for the purpose of criticising the construction of the trap, or the way in which the proprietor runs his business; while the other half, seeing the amount of business he is doing, rushes back to the factory, and insists on adding a competing model to their own line. Truly, variety is the spice of life, but like most kinds of spice, it is expensive—especially when you think of the huge inventories, the idle stocks, the idle investment, the slow turnover, and the heavy carrying charges imposed by too many sizes and styles in any one line of goods.

Associations Aiding Movement of Simplification

Since early in Mr. Hoover's secretaryship, the Division of Simplified Practice has been co-operating with several industries through their trade associations in the eliminating of unnecessary varieties in their products. For example, the paving brick manufacturers were making 66 different sizes and types of paving bricks and spending more time and money competing with each other than with their real competitors, viz., the manufacturers of other kinds of paving material. They found 80 per cent of their business since the war had been done in only 20 per cent of the line. So with the help of the Division they perfected an agreement with their distributors, and their consumers, as represented by the highway engineers of the several states and municipalities, to discontinue manufacturing the 55 bricks that meant so little to them, and concentrate production, sale, and use on the 11 most popular sizes. Six months later they came back and reduced the line to

7, and last year they reduced it to 6. Their business has grown steadily, their costs have come down, and their profits have increased accordingly. Other simplifications accomplished to date are:

1. Building bricks reduced from 39 sizes to 1.
2. Hollow building tile, formerly made in 36 sizes, each in a variety of weights, is now made in 19 sizes, each having a standard weight.
3. Metal lath has been reduced from 80 varieties to 12.
4. Asphalt for road use, from 88 grades to 9.
5. Range boilers, from 130 sizes to 13.
6. Woven wire fence, formerly made in 552 styles and put up in 2072 different packages, is now made in 69 styles and 138 packages. The manufacturers, distributors, and in many cases, the consumers, have been loud in their praises of the results of these simplifications.

The chief of the Division of Simplified Practice, William A. Durgin, recently succeeded in bringing simplification into the lumber industry, which, with its great variety of kinds and grades, and its unlimited number of thicknesses for one-inch boards, certainly was in need of simplification. Secretary Hoover estimates the savings to the industry and the public through this reduction of unnecessary variety will amount to $250,000,000 a year.

Many Lines of Products Under Survey

Surveys of existing varieties are now under way in 25 different lines, including steel barrels, garden hose, clay products, baggage, ice cream cans, milk cans, United States flags, hospital beds, gas water heaters, (side arm type, and flueless type), combination boilers and gas water heaters, spices, flavoring extracts, steel lockers, auto tank and radiator cap sizes, coffee, paint and varnish brushes, shovels, sheet steel, terne plates, conductor pipe and eaves trough, surgical instruments, grocery paper bags, piano parts, builders hardware, including bolts, butts, locks and shelf hardware.

Committees are at work in nearly a hundred other fields, and the application of simplified practice is increasing rapidly as its capacity for opening up hitherto hidden sources of profits become more generally understood. From the beginning of this work, the Chamber of Commerce of the United States has strongly en-

dorsed, and encouraged the broader application of simplified practice as a waste-eliminating measure. It has also done much to demonstrate the practicability of this sort of co-operation between government and industry.

Simplification Preliminary to Standardization

Standardization usually means crystallizing the best thought and practice of the industry into a few definite forms or types of products for general use. There can be simplification without standardization; but you cannot arrive at the ideal type in any product without first eliminating or discarding a lot of superfluous and nonessential varieties. Standardization is a process of evolution in which only the fit survive. Among men, methods, materials, only those best equipped for the conditions of the race, only those having certain qualities required for successful service are present at the top of the heap, after having been fairly weighed in the balance. In the crucible of economic wants, everything is tested by its capacity to afford the greatest satisfaction; only in that way do things become "standard."

Insofar as standardization means interchangeability, it is not a new subject. Early in the seventeenth century the Dutch shipbuilders applied the principle of having the various parts of ships made at different production centers, from which they were transported by canal to assembling yards or plants on the seacoast. Alfred Marshall, the greatest English economist since the days of Adam Smith, points out in his book *Industry and Trade*, that it was by this method that the Dutch were able to compete successfully with the English and the Italian merchant marine of those days. We did not learn this lesson until we began to build standardized ships at Hog Island 300 years later. Now we have an American Marine Standards Committee, organized under Secretary Hoover's direction, which is making real headway in taking shipbuilding out of the custom-tailoring class, and setting it up on a quantity production basis.

It is not so many years ago that each of our railroads was built with a different gage of track to prevent cars of other lines passing over its rails. But finally, in answer to public demand for through service, the gages were unified, but it cost a great deal of money as well as some blood and tears. At Erie, Pennsylvania there was

a regular battle between the section gangs of the railroads and the teamsters who made their living hauling the goods from the cars on one line to those on the other. Today we find men in various industries ready to fight when you mention standardization, for they feel it will destroy the individuality of their products. Obviously, no one with common sense is going to propose that everything be standardized, even to the feathers in women's hats but there are a great many opportunities for practical standardization. When the American Engineering Standards Committee at Secretary Hoover's request, made a canvass of its member bodies for their suggestions, the American Society of Mechanical Engineers reported over one thousand different items in which a greater degree of standardization and interchangeability would bring vast economic advantages and benefits, not only to the industries concerned but to the public at large.

The National Screw Thread Commission and the National Board of Fire Underwriters have been working for years to standardize fire hose couplings, and to get the municipalities to adopt them, so that when conflagrations occur, apparatus from neighboring cities can be utilized effectively. Our annual fire loss runs over $500,000,000 a year, yet only about one-fourth of the towns of the United States are using the standard coupling.

In the electrical field, about the only item that is really standardized is the lamp base and its socket. Yet with all the effort the utility companies are making to increase the use of electricity, not only in city homes but even on the farms, would you not think they would make more effort to standardize the appliance end of the attachment cord, so one would not have to use a different type of plug for the toaster, another one for the washing machine, another for the curling iron, and so on.

In the automotive field, many details of construction are relatively standardized—tire sizes, spark plug sizes, etc—but there is much that can be done to facilitate repairs and lower maintenance cost without destroying that individuality that is inherent in the Rolls Royce, or the flivver. The Standards Committee of the Society of Automotive Engineers and our National Bureau of Standards, of which your president, Doctor Burgess, is director, are doing some very effective work along this line. It is a well-known fact that through standardization of products, processes,

methods and materials, in this great industry, we are offered better cars at lower prices than have ever been quoted before, for equivalent value. Standardization has enabled this industry to jump to the forefront of all our industries in less than 25 years and according to a survey by the standards department of the Society of Automotive Engineers, the manufacturers participating in the work of the society saved through standardization approximately $750,000,000 in 1921. Part of that sum appeared in the form of increased dividends, but a large part was passed along to the consumer, which explains why car prices are lower and quality is improving all of the time. In other fields, the work is going on rapidly; quietly, but persistently. As there is nothing spectacular in standardization, it makes it difficult to tell the story without making it tiresome. However, in the development of the art of cutting metal, there is a story of patient and painstaking research which covers an achievement eventually worth millions to American manufacturers. This work is being done by the American Society of Mechanical Engineers, assisted by the American Society for Steel Treating, the American Society for Testing Materials, the National Machine Tool Builders association; our Bureau of Standards, and other bodies. The joint committee is developing standard methods for testing tool material, and the material to be cut; also standard heat-treating methods; standard tool forms or designs, standard methods for testing tool performance, etc. In time, this committee's work will mean great savings to the American public through the consequent lowering of production costs.

Standardization Applied to Government Activities

Consider standardization from the taxpayers' pet aversion; "the high cost of government." Not long ago each federal department bought whatever it wanted, as and when it pleased. But with the establishment of the Bureau of the Budget to keep some check on government expenditures, there was set up a General Supply Committee to govern the purchase and distribution of supplies. All requirements for all departments are handled by this committee, and goods are now bought in quantities at lower prices, because of this centralizing of purchasing. Obviously, standard specifications were needed and the Federal Specifications Board was organized with Dr. Burgess as chairman. This board, com-

posed of experts from each federal department, prepares the specifications covering the standard supplies used by the government; thus the taxpayer is getting better value for his money, though he is not paying lower taxes as yet. Nevertheless, it is through such economies that the tax reductions now under discussion, are made possible.

We have 48 state governments, each buying according to its own ideas of what it needs. The Federal Specifications are not followed by the states, nor are those of any one state. The same situation exists in municipal and in institutional purchasing. Last July, Secretary Hoover invited the city, the state, and the government purchasing agents to meet with him. They did, and out of the recognition of the tremendous possibilities for nation-wide economy in the standardization of their respective specifications, came a committee to co-ordinate the work of these several groups. The committee has begun its work by making a comparison between the specifications used by the federal government, the state and municipal governments, the public institutions, also the important national trade associations and technical societies, with the view to harmonizing and standardizing their present widely divergent specifications. This will also mean great savings to manufacturers, and to the public through encouraging the manufacture, sale and use of standard goods. The peace time purchases of these groups run to over $1,500,000,000 a year. In time of war, procurement of supplies will be greatly helped by the increased availability of standard goods made possible when all government specifications call for articles of commercial production; rather than "of special design and construction" as has been the case heretofore. These unified specifications will be published in a handbook or "dictionary of standards" and from the interest and enthusiasm shown by the manufacturers, the purchasing agents, the engineers and others, it promises to become a very popular and useful book of reference.

The American Engineering Standards Committee is also doing very effective work in developing standards and encouraging their application. Time will not permit a detailed review of the results of its efforts, but the American Engineering Standards Committee has nearly 150 industrial standardization projects under way, and there are over 200 national bodies, technical, industrial, and govern-

mental, co-operating in the work through officially accredited representatives. In all those activities the work of developing standards is being co-ordinated and unified to avoid overlapping and duplication.

The American Engineering Standards Committee maintains contact with the National Standardization bodies of 19 foreign countries, and in some cases, definite steps toward international standardization have been taken. For example, in regard to ball bearings, definite proposals have been formulated by the American committee and presented to the foreign bodies as a basis of international agreement.

Conclusion

In conclusion, permit me to review briefly the benefits of simplification and standardization:

1. A decrease in capital investment in all branches of trade, and in individual plants, through decrease in inventories of tools, patterns, finished products, etc.

2. Elimination of waste in experimentation and designing, because of the increased availability of the great mass of information based on scientific investigation of what constitutes the best in current practice.

3. More speedy and reliable deliveries because a manufacturer will feel safe in producing for stock in dull seasons, for he knows standardized goods will sell the year round.

4. General decrease in prices. Lack of standardization in a trade makes it a specialty trade and any specialty trade is distinctly a high-priced trade. All costs are higher than is the case when standardized goods are made by mass production methods.

5. The introduction of new processes and machinery is expedited. In many industries today, the lack of standardization prevents the introduction of machine methods, etc., as the run of work is not sufficient to pay for such machinery, yet the constant changing of "set-ups" is recognized as a large expense or burden factor.

6. The elimination of false and wasteful ideas prevalent in trade, relative to design, quality, etc. Think of how many articles are put on the market because of the false notion that their sale rests on their being different in some detail from other articles of the

same general class; such essentials as maximum utility, quality, service and ability to give greatest satisfaction often being overlooked, if not entirely forgotten.

7. Decrease in ruinous competition due to ignorance. Standardization means more dependable advance estimates of quality, cost and time delivery. It automatically makes better cost systems possible and therefore more likely to be installed. The net result is the elimination of uncertainty and ignorance which results in bids, quotations, and promises which cannot be met by the reliable manufacturer.

America is in a fortunate position today. Other great manufacturing countries have not yet regained their prewar position in world trade, but they are gradually recovering. If we want to keep the lead we hold today, we need to apply simplication and standardization as far as we can do so practically, and thus enable us to meet this competition. Not only that, our own population is growing rapidly; the problem of developing and maintaining greater economic independence is essential, in order that more of our people may have more of the necessities and comforts of life, and thus advance their standards of living. The most weakening influence on national morale is the lowering of the living standards of a nation's people.

When the Federated American Engineering Societies made their survey of waste in industry two years ago, they found an average waste of 50 per cent in 6 of our leading industries. Applying this factor to our fabricated production, which amounted to over $60,000,000,000 in 1921, we have an annual waste in industry of at least $30,000,000,000. Leading industrial engineers and management experts have estimated that one-third of this waste, or $10,000,000,000 can be eliminated by a more intensive application of simplification and standardization in all of our industries.

For all of these reasons, it is vital that manufacturers, merchants, engineers, and business men everywhere co-operate with our scientists, in simplification and standardization, so that we, as a nation, may maintain our industrial stability, our commercial supremacy, and our national prosperity.

WHAT IS CASE DEPTH?

By S. P. Rockwell and Frederick Downes

Abstract

This paper shows the variations which are normally obtained by various methods of measuring carburized case depths, using five standard steels under two different lengths of time, handled according to good hardening shop practice. It is an endeavor to show the necessity for more accurate specifications as regards case depth. Much interesting data can be derived from careful study of the charts and various information recorded.

Introduction

SPECIFICATIONS indicating the required case depth of a given piece of material or machine part, are seldom followed out to the letter. This is largely due to fact that different hardeners or manufacturers measure case depth by different methods. Many of these specifications are drawn up by engineers who have had little or no metallurgical experience, or who have not secured the counsel of metallurgists or hardeners, on the subject. Instances have occurred where the case depth has been specified at 1/32 inch and the hardener has governed his results by fracture, while the inspector has passed on the results as reported by the metallographist.

The object of this investigation was to determine, if possible, whether any relationship existed between different steels under different methods of measuring the case depth. There are numerous methods of depth measurement, some of them more important and more commonly used than others. The most generally used methods may be enumerated as follows:

(1) A sample taken from the carburizing pot, quenched directly, broken, and the depth of case estimated by the eye.

(2) A sample taken directly from the carburizing pot, quenched or cooled slowly,

A paper presented at the fifth annual convention of the Society, Pittsburgh, Oct. 8-12, 1923. Of the authors, S. P. Rockwell is consulting metallurgical engineer, Hartford, Connecticut and Frederick Downes is chief metallurgist, New Britain Machine Co., New Britain, Connecticut.

single or double treated, broken, and the depth of case estimated by the eye.

(3) The samples enumerated under (1) and (2) polished and etched with acid and a scale measurement made of the case depth.

(4) The samples enumerated under (3) examined and the case depth measured with the aid of the microscope.

In this work, five major case-hardening steels recommended by the Society of Automotive Engineers were selected for test. It was decided to follow a good commercial practice in carburizing the specimens, (such as can be secured in any well equipped heat-treating plant) rather than to follow purely laboratory procedure. For this purpose the following steels were taken:

S. A. E. 1015, S. A. E. 2315, S. A. E. 3115, S. A. E. 6120, 5 per cent nickel case-hardening steel, equivalent to S. A. E. 2512.

Procedure

All bars used in test were turned to ½-inch diameter from oversize stock before carburizing. Five different types of steel were used, each type being stamped with a number for identification. The following table gives the analysis of all steels, each specimen bearing a certain composition number:

	C.	Mn.	P.	S.	Si.	Ni.	Cr.	V.
1.....	0.13	0.27	0.010	0.035	0.055	....	....	....
2.....	0.18	0.64	0.010	0.040	0.161	3.53	....	....
3.....	0.13	0.38	0.015	0.028	0.112	1.06	0.67	....
4.....	0.16	0.35	0.011	0.027	0.222	....	0.99	0.18

5.....5 per cent nickel case-hardening steel (exact analysis not determined).

A bar of each of the steels, properly sawed to facilitate fracturing later, was put into each of two carburizing boxes in manner indicated in Fig. 1. Short sections of each of the steels were also put into each box. These latter sections had wires attached to them so that when the time at heat for the load was reached the box might be removed from the furnace, and the sections withdrawn and quenched. The longer bars were allowed to cool slowly in the carburizing mixture after the box

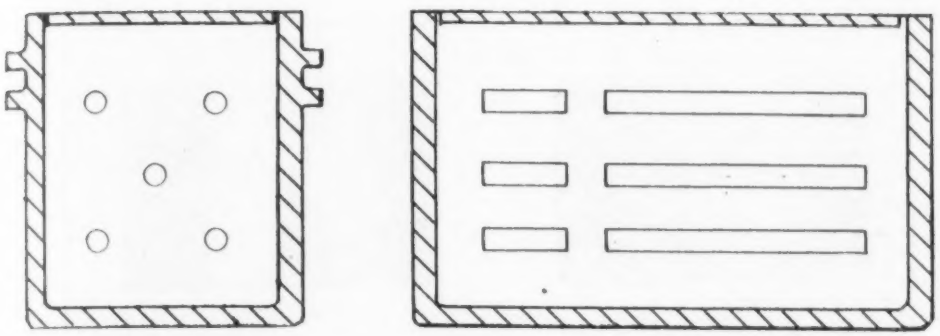


Fig. 1—Diagram showing the arrangement of specimens in carburizing box.

had been resealed. The carburizing compound used was a typical commercial material, and the temperature of the furnace during the heat was 1700 degrees Fahr.

After cooling in the carburizing mixture, the bars were removed and each set given the following treatment: A section of the pot-cooled bar was broken off and hardened at the case refining temperature. Another section was then treated for core refinement and case-hardness. These two sections together with the pot-cooled specimen and the pot-quenched specimen gave, when fractured, four different conditions in the same steel, and these same conditions were represented by two different case depths for each steel. This gave in all, 40 fractured specimens. For identification of the treatment which any given specimen received, each fractured specimen had, in addition to its composition number, a letter indicating its treatment as shown in the following table.

Letter	Time of carburizing temperature	
A	5 hours	Quenched from pot in oil.
B	5 hours	Cooled in pot.
C	5 hours	Cooled in pot and treated for case only.
D	5 hours	Cooled in pot and treated for case and core.
E	9½ hours	Quenched from pot in oil.
F	9½ hours	Cooled in pot.
G	9½ hours	Cooled in pot and treated for case only.
H	9½ hours	Cooled in pot and treated for case and core.

Characteristics of Carburized S. A. E. 1020 Steel

Quenching this steel from the pot into oil, causes formation of areas of the constituents, martensite and troostite. After the 5-hour heat, free cementite is not present in either

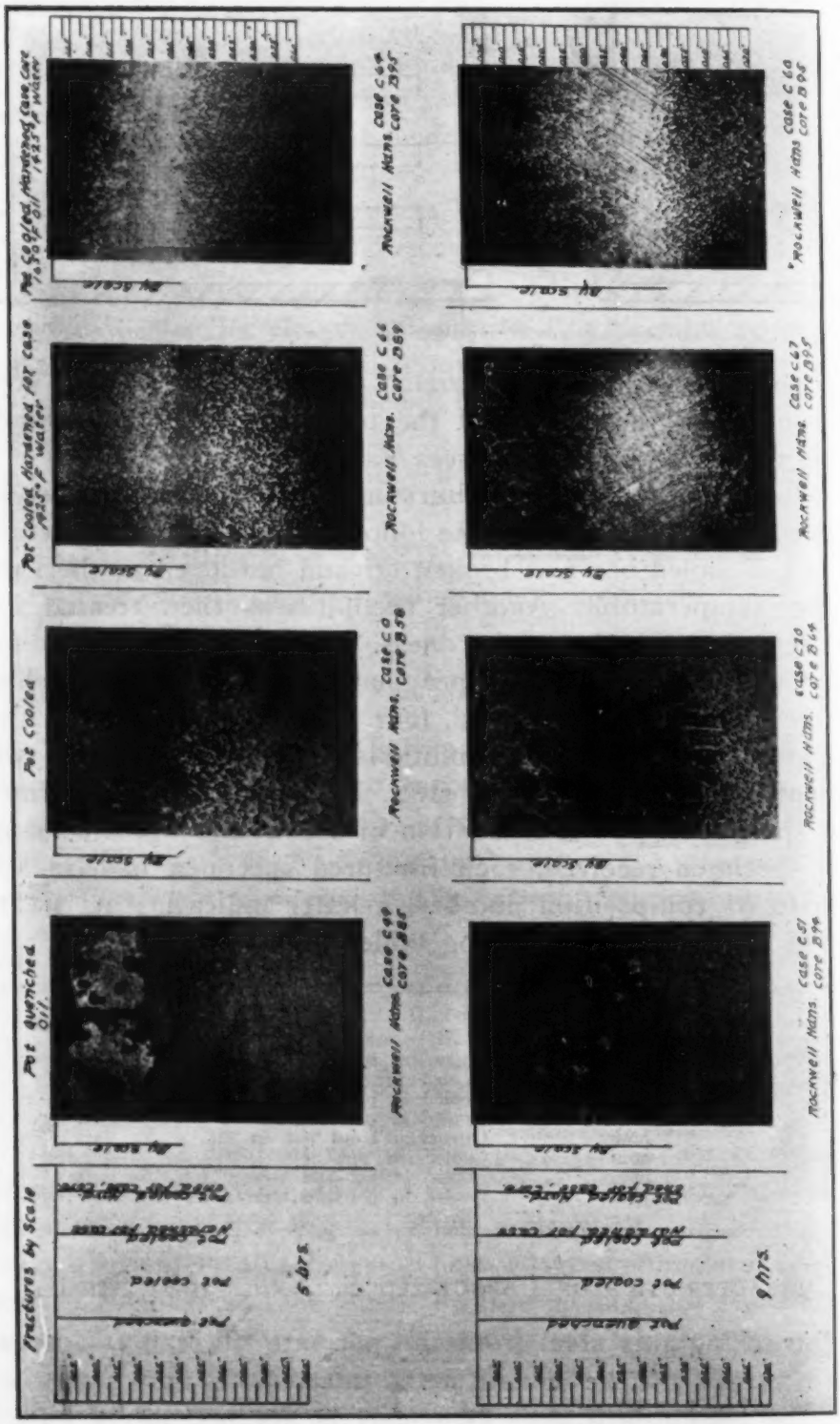


Fig. 2—Photomicrographs of S. A. E. 1020 steel showing the depth of carbon penetration, after a 5-hour and 9½-hour carburizing treatment at 1700 degrees Fahr. The several methods of measuring case depth as described in this paper are shown.

the single or double heat treatments, and after the 9½-hour heat, free cementite is not noticed in the double heat treatment.

The steel shows signs of abnormality as indicated by the 5-hour pot-cooled sample, Fig. 2. With the exception of the

Table I

Numbering System, Temperatures and Treatment Applied to Test Specimens

Carburized 5 hours	Carburized 9½ hours	Treatment
1A	1E	
2A	2E	
3A	3E	Quenched from pot in oil.
4A	4E	
5A	5E	
1B	1F	
2B	2F	
3B	3F	Cool in pot.
4B	4F	
5B	5F	
1C	1G	Cooled in pot. Reheated to 1425 degrees Fahr. Quenched in water.
2C	2G	Cooled in pot. Reheated to 1400 degrees Fahr. Quenched in oil.
3C	3G	Cooled in pot. Reheated to 1425 degrees Fahr. Quenched in oil.
4C	4G	Cooled in pot. Reheated to 1325 degrees Fahr. Quenched in oil.
5C	5G	Cooled in pot. Reheated to 1450 degrees Fahr. Quenched in oil. (Not high enough temperature.)
1D	1H	Cooled in pot. Reheated to 1650 degrees Fahr. Quenched in oil. Reheated to 1425 degrees Fahr. Quenched in water.
2D	2H	Cooled in pot. Reheated to 1525 degrees Fahr. Quenched in oil. Reheated to 1400 degrees Fahr. Quenched in oil.
3D	3H	Cooled in pot. Reheated to 1575 degrees Fahr. Quenched in oil. Reheated to 1425 degrees Fahr. Quenched in oil.
4D	4H	Cooled in pot. Reheated to 1650 degrees Fahr. Quenched in oil. Reheated to 1325 degrees Fahr. Quenched in oil.
5D	5H	Cooled in pot. Reheated to 1650 degrees Fahr. Quenched in oil. Reheated to 1500 degrees Fahr. Quenched in oil.

pot-cooled sample, 9½-hour heat, hardened for case, the case depth after heat-treatment is greater by microscope, by scale of etch and by scale of fracture. (Fig. 2.)

The pot-cooled samples show in general, the least depth of case. The hardest case is obtained by hardening for case only. With the 5-hour heats, the sample hardened for case

and core shows the hardest core. In the 9½-hour heats there is but little difference.

Characteristics of Carburized S. A. E. 2315 Steel

Fig. 3 shows that the single and double heat-treatments have removed the hypereutectic structure. Double heat-treat-

Table II

S. A. E. 1015 Steel Carburized for 5 Hours

	Depth Measurements in Inches				
	Scale		Micro-	Hardness-	
	Fracture	Etched	scope Etched	Rockwell Case	Core
Pot quenched 1A	0.0315	0.0305	0.040	C 49	B 85
Pot cooled 1 B	.....	0.0285	0.033	C 0	B 58
Pot cooled, hardened for case 1 C	0.034	0.032	0.038	C 66	B 89
Pot cooled, hardened for case and core 1 D	0.036	0.031	0.037	C 64	B 95
S. A. E. 1015 Steel Curburized for 9½ Hours					
Pot quenched 1 E	0.046	0.0475	0.047	C 51	B 94
Pot cooled 1 F	0.035	0.040	0.062	C 20	B 64
Pot cooled, hardened for case 1 G	0.060	0.0465	0.061	C 67	B 95
Pot cooled, hardened for case and core 1 H	0.048	0.048	0.055	C 60	B 95

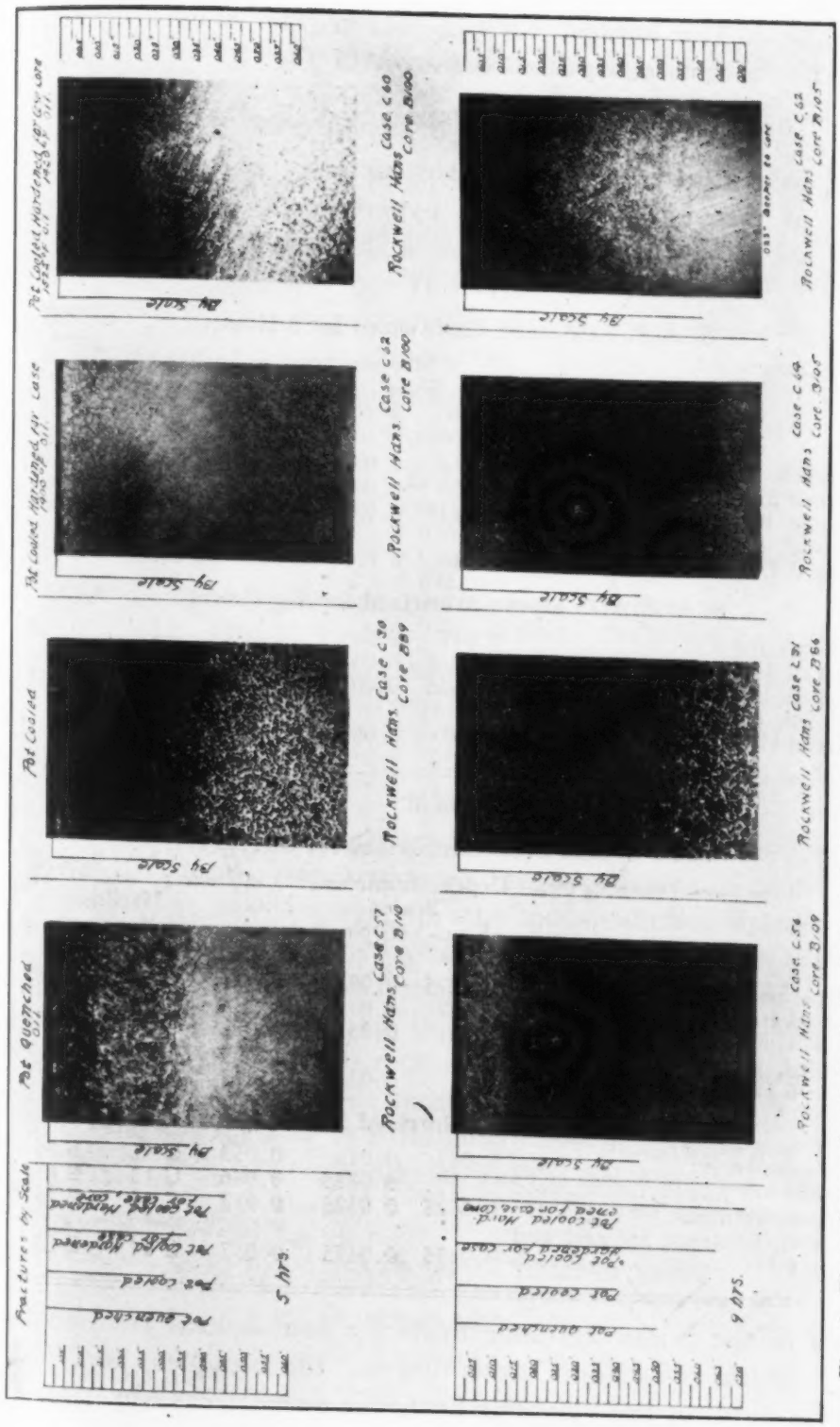
Table III

S. A. E. 2315 Steel Carburized for 5 Hours

	Depth Measurements in Inches				
	Scale		Micro-	Hardness-	
	Fracture	Etched	scope Etched	Rockwell Case	Core
Pot quenched 2 A	0.036	0.0365	0.045	C 57	B 110
Pot cooled 2 B	0.0305	0.0315	0.042	C 30	B 89
Pot cooled, hardened for case 2 C	0.036	0.0365	0.050	C 62	B 100
Pot cooled, hardened for case and core 2 D	0.045	0.0415	0.053	C 60	B 100
S. A. E. 2315 Steel Carburized for 9½ Hours					
Pot quenched 2 E	0.049	0.046	0.047	C 56	B 109
Pot cooled 2 F	0.040	0.040	0.050	C 31	B 86
Pot cooled, hardened for case 2 G	0.0635	0.045	0.056	C 64	B 105
Pot cooled, hardened for case and core 2 H	0.071	0.060	0.0575	C 62	B 105

ment gives the greatest depth by microscope, by scale measurements of etched specimen, and by scale measurements of fracture.

The pot-cooled samples in general show the least depth


Fractures by Scale
Pot Quenched
Pot Cooled
Pot Cooled Hardened
Pot Cooled Hardened for Case
Pot Cooled Hardened for Case and Core
5 hrs.
9 hrs.
Rockwell Hdns. Case C 57 Core B 110
Rockwell Hdns. Case C 56 Core B 109
Rockwell Hdns. Case C 50 Core B 89
Rockwell Hdns. Case C 54 Core B 94
Rockwell Hdns. Case C 52 Core B 100
Rockwell Hdns. Case C 64 Core B 95
Rockwell Hdns. Case C 60 Core B 100
Rockwell Hdns. Case C 62 Core B 105
Pot Cooled Hardened for Case
Pot Cooled Hardened for Case and Core
Pot Cooled
Pot Quenched

in case, while the hardest case is obtained in the single heat treatment. The hardest core is obtained by quenching from the pot. The case depths are shown in Fig. 3.

Characteristics of Carburized S. A. E. 3115 Steel

Examinations of the microstructures obtained in this series of tests shows that the hypereutectic structure is re-

Table IV

S. A. E. 3115 Steel Carburized for 5 Hours

	Depth Measurements in Inches				
	Scale		Micro-	Hardness-	
	Fracture	Etched	scope Etched	Rockwell Case	Core
Pot quenched 3 A	0.036	0.035	0.042	C 60	B 101
Pot cooled 3 B	0.030	0.030	0.037	C 26	B 83
Pot cooled, hardened for case 3 C	0.0425	0.039	0.040	C 59	B 96
Pot cooled, hardened for case and core 3 D	0.046	0.039	0.041	C 58	B 95
S. A. E. 3115 Steel Carburized for 9½ Hours					
Pot quenched 3 E	0.047	0.047	0.062	C 59	B 103
Pot cooled 3 F	0.0465	0.0575	0.060	C 41	B 80
Pot cooled, hardened for case 3 G	0.0635	0.055	0.065	C 58	B 95
Pot cooled, hardened for case and core 3 H	0.061	0.060	0.066	C 51	B 94

Table V

S. A. E. 6120 Steel Carburized for 5 Hours

	Depth Measurements in Inches				
	Scale		Micro-	Hardness-	
	Fracture	Etched	scope Etched	Rockwell Case	Core
Pot quenched 6 A	0.0275	0.033	0.041	C 35	B 80
Pot cooled 6 B	0.017	0.020	0.032	C 7	B 63
Pot cooled, hardened for case 6 C	0.031	0.033	0.042	C 30	B 80
Pot cooled, hardened for case and core 6 D	.....	0.033	0.043	C 20	B 85
S. A. E. 6120 Steel Carburized for 9½ Hours					
Pot quenched 6 E	0.045	0.046	0.050	C 41	B 85
Pot cooled 6 F	.....	0.0355	0.046	C 13	B 67
Pot cooled, hardened for case 6 G	0.0525	0.0525	0.052	C 35	B 75
Pot cooled, hardened for case and core 6 H	0.0475	0.0475	0.057	C 28	B 83

moved in the 5 and 9½-hour heats by double heat treatments only. With one slight exception in the samples hardened for case only, in the 9½-hour heat, the deepest case by micro-

scope, by scale of etched specimen, and by scale of fracture, is with the double treated specimens. The pot-cooled samples in general show the least case depth. The hardest case appears with the pot-quenched specimen, and the hardest core appears with the pot-quenched specimen.

Characteristics of S. A. E. 6120 Steel

Fig. 4 shows photographs of the structures and case depths of the specimens treated. They show that double

Table VI

S. A. E. 2512 Steel Carburized for 5 Hours

	Depth Measurements in Inches				
	Scale		Micro-	Hardness-	
	Fracture	Etched	scope Etched	Rockwell Case	Core
Pot quenched 5 A	0.028	0.030	0.035	C 57	B 109
Pot cooled 5 B	0.0155	0.0185	0.033	C 21	B 89
Pot cooled, hardened for case 5 C	0.038	0.0335	0.035	C 61	B 96
Pot cooled, hardened for case and core 5 D	0.0375	0.0335	0.038	C 61	B 103
S. A. E. 2512 Steel Carburized for 9½ Hours					
Pot quenched 5 E	0.045	0.0465	0.047	C 54	B 109
Pot cooled 5 F	0.0265	0.029	0.037	C 31	B 92
Pot cooled, hardened for case 5 G	0.064	0.0465	0.060	C 62	B 100
Pot cooled, hardened for case and core 5 H	0.0225	0.065	0.062	C 62	B 100

treatment is effective in removing the hypereutectic structure, although it is not apparent in the pot-quenched specimens. The single treatment samples appear to have slightly greater case depth under different methods of measurement, while the pot-cooled samples show in general the least case depth.

It is not feasible to remark upon the hardness of the case of these specimens because they should have been water quenched. There is little advantage in core hardness by any of the quenched specimens except in the case of the double-quenched specimen.

Characteristics of S. A. E. 2512 Steel

The data obtained in these tests show all samples to be quite free of hypereutectic structure. In general the greatest depth by microscope, by scale of etched specimen and by scale

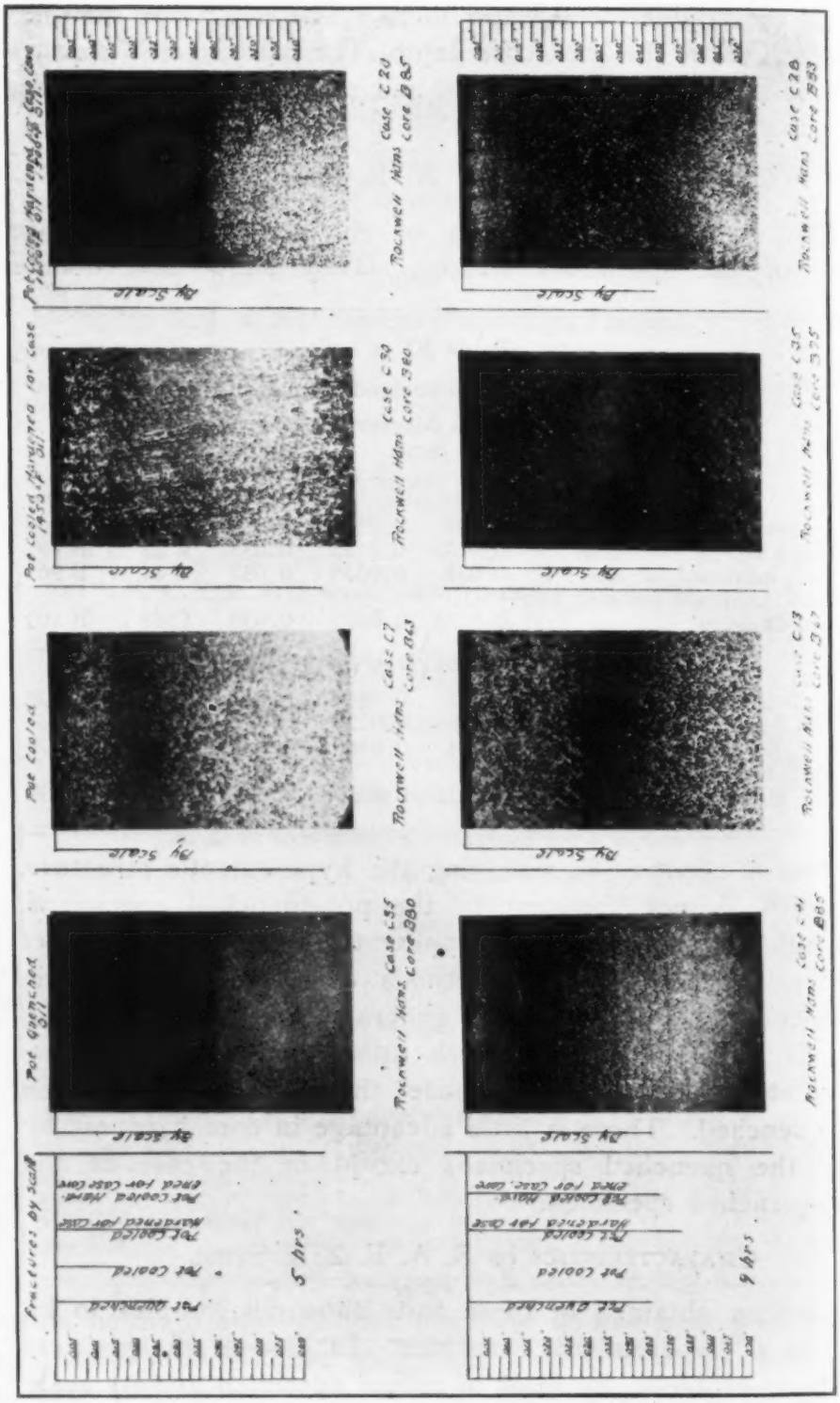


Fig. 4.—Photomicrographs of S. A. E. 6120 steel showing the depth of carbon penetration, after a 5-hour and a 9½-hour carburizing treatment at 1700 degrees Fahr. The several methods of measuring case depth as described in this paper are shown.

of fracture appears with the double-treated specimen. The pot-cooled samples in general show the least case depth, while the hardest case is obtained with the heat-treated specimen, after pot-cooling specimens. The hardest core is obtained with the pot-quenched specimens.

Conclusions

The principal conclusions to be drawn from the data obtained in these tests are:

1. Examination of pot-cooled samples by the microscope or by the scale, (which is not always practical) shows that measurement at this stage is indicative of a case depth considerably less than quenched samples.

2. In general the double treated specimens show the greatest depth of case by the various measurements. This is particularly true of the alloy steels.

3. It appears that there is as much as 70 per cent difference in measuring case depth by different methods and different heat treatments.

4. In general as regards hardness of case, the single treated specimens show the greatest hardness.

5. In general the core hardness of the pot-quenched specimen is harder than specimens subsequently quenched.

6. This report aims to show the necessity for a more definite set of specifications to describe case depth.

Discussion of Messrs. Rockwell and Downe's Paper

CHAIRMAN d'ARCAMBAL: Mr. Rockwell's paper is one of great interest to us, for scarcely a day goes by that we do not take test specimens from the carburizing boxes and in some way attempt to measure the depth of case that is obtained. I would like to have you gentlemen get up and state briefly just what method you use in measuring the depth of case in every-day practice, that is, if you harden and fracture, measure the case depth under the microscope, or what method you use, in order to determine if we can the method that is most commonly used in this country. This paper is now open for discussion.

PROF. H. M. BOYLSTON: I would like to ask Mr. Rockwell what constitutes the depth of case in a given carburized steel? What is the criterion for getting the depth of the case? There are differences of opinion as to how far into the steel one should measure, and in most

of the cases I have observed the line or zone to which the depth of case is measured is rather an arbitrary one.

S. P. ROCKWELL: You mean by the microscope?

PROF. H. M. BOYLSTON: Any method at all.

S. P. ROCKWELL: I think a fractured, polished and etched specimen shows a well defined case when observed by the eye. If you were to measure this by the use of a scale, there might be a slight slippage in obtaining readings, but you could obtain the depth very closely. In using the microscope the observer must determine what constitutes the case depth.

PROF. H. M. BOYLSTON: I know of one specification where the case was considered to begin where the carbon content was double that of the core. Is that a fair way to test case depth, or is that going too far in toward the core?

S. P. ROCKWELL: That is a question that I cannot answer.

CHAIRMAN d'ARCAMBAL: May I ask, Mr. Rockwell, which type of steel showed the greatest depth of case under the same conditions?

S. P. ROCKWELL: I think the Society of Automotive Engineers 2512, the 5.50 per cent nickel, showed the greatest depth. The 3.5 per cent nickel, next.

CHAIRMAN d'ARCAMBAL: That, of course, is contrary to all theory.

Mr. Northrup, of Hudson Motor Car Co., how do you measure case depth in every-day practice?

H. M. NORTHRUP: We observe the fracture. We judge it under the microscope, and generally measure from the zone where a marked increase in carbon content exists between the case and the core. I would say it is generally a matter of personal opinion, but we usually measure from the zone which shows a marked increase in carbon content.

CHAIRMAN d'ARCAMBAL: In every-day practice do you place a test specimen in your pot, remove, harden, and fracture the same?

H. M. NORTHRUP: Yes.

CHAIRMAN d'ARCAMBAL: That is the method most commonly used, I believe.

Mr. Lanning, of the New Departure Co., what method do you use?

L. A. LANNING: In our regular routine testing we use a double treated specimen taken from the pot. That is, a piece is withdrawn from the pot when we assume it has been there about the correct length of time and we cool it in the air. It is then re-heated and hardened in oil and then re-heated and quenched in water. The depth of fracture is judged by the eye.

CHAIRMAN d'ARCAMBAL: Do you use a scale or anything to measure that depth?

L. A. LANNING: No, it is usually estimated by the eye, and the judgment of the observer.

CHAIRMAN d'ARCAMBAL: Mr. Spalding, in your trips around the country what method do you find most frequently used?

S. C. SPALDING: I think the method that is used most is the examination of the fracture of a test piece. By the usual method a test piece is taken out of a pot and cooled in the air, then single-quenched, fractured and the depth of case estimated, not measured. In some instances the case depth is measured, but in many cases there is no scale or anything used to measure the depth, simply the man who is practiced in judging the effect of the carburizing heats judges whether the case has the thickness that is wanted.

In microscopic observation I have never heard of the method of taking double the carbon concentration, that was in the original sample, as a starting point. The starting point that I usually use is that which is about half way between where there is some increase in carbon content and where there is a total absence of ferrite in the structure.

S. P. ROCKWELL: I think the explanation ought to be made that in a great many carburizing operations that even a fifty per cent variation in the depth is not detrimental to the work but there are a lot of fabricated parts where depth has to be drawn down very close for the strength and other qualities of the section. The thinner the work the more important becomes correct depth and strength measurements.

A. V. de FORREST: A good deal of work has been done on a magnetic test, correlating the magnetic test with the depth of hardness, and it became apparent that the depth of hardness as seen by the fracture and as determined by the etched specimen, varied in its ratio according to something that we did not determine. It was very variable. Looking at a few hundred specimens, for instance, there would be 50 per cent variation in the difference between the two methods of determining the depth, and we have found that the depth as determined by the single-quench fracture was quite misleading if the gradation from the highly concentrated case was gradual. It comes down to a question of what the gradation is, as to the point from which you start measuring case depth on the quenched fracture.

I might say that the magnetic method correlates with something which is very useful as an indication of a depth of case.

CHAIRMAN d'ARCAMBAL: Your magnetic test was made on the hardened specimen?

A. V. de FORREST: Yes.

CHAIRMAN d'ARCAMBAL: Mr. Allen of Rolls-Royce, how do you measure depth of case in daily routine practice? How do you check your case depth?

R. J. ALLEN: By simply quenching the test specimen directly

from the pot in water and reading the fracture. I did not hear the paper, as I just came in a moment ago, consequently I am not in a position to discuss it.

CHAIRMAN d'ARCAMBAL: You use a good deal of 5.0 per cent nickel steel, do you not?

R. J. ALLEN: Entirely, for all carburized parts.

S. P. ROCKWELL: I might say the 5.0 per cent nickel sample that you furnished is the one that shows the greatest variation in the depth measurements.

R. J. ALLEN: That is rather interesting. I am sorry I did not hear the paper.

CHAIRMAN d'ARCAMBAL: Mr. Stillwell of Dodge Brothers, what method do you use in measuring case depth?

E. STILLWELL: In every furnace load we put four samples in the various parts of the furnace, and we have a standard time for every part, and take one sample out and cool it on the floor and reheat it in cyanide or lead, quench it in water, and examine the fracture. If there is any question of a doubt, we etch it in a weak solution of nitric acid and wood alcohol. This determines whether the pots are ready to come out. I have also found, that on a polished specimen etched in picric or nitric acid, that the specimen does not show up with as heavy a case as it does under the fracture test.

CHAIRMAN d'ARCAMBAL: We still have about five minutes more, gentlemen, for further discussion. This is a subject everybody is vitally interested in. We come hundreds of miles to hear these papers, and here is your opportunity to get up and ask questions.

A. L. DAVIS: I can tell you a little something from a service heating concern that I am connected with. Very often they are asked to do carburizing work to a specified depth, and I am quite sure in all cases there, that the actual fracture test, in case of a dispute, settles it. I have never heard of their going to the microscope. If a man says he wants a sixteenth-inch case, the sample is hardened, broken, and if it shows that by eye, it is accepted, or backed up by a measurement with the steel rule.

S. P. ROCKWELL: Irrespective of the steel, Mr. Davis?

A. L. DAVIS: Yes. So far as I know the microscope has never been used. Of course, the great bulk of our work is just plain, soft low carbon steel.

CHAIRMAN d'ARCAMBAL: Dr. Johnson, have you any remarks you would like to make on the subject?

DR. C. M. JOHNSON: Mr. Chairman, our work in case carburizing is purely experimental; it is along research lines, so the only remark that I would like to add is that in cases of dispute, additional accuracy could be obtained by using an ordinary hand magnifying glass. The simpler you can make such tests, I think the better it is. The adding of the microscope, of course, means considerable time

consumed in making tests. It would have to be resorted to in cases of dispute, but for practical, every-day work you have all heard the report of men who make this a regular business, and it seems to me their methods should be adopted as standard rather than running this thing too far into technical methods, which consume too much time for every-day, standard practice.

W. D. FULLER: Referring to Dr. Johnson's remarks, it would seem that any inspection of case depth by eye, would necessarily mean that you would determine the depth of case by the degree of fineness of the structure, and it would seem that in alloy steels and in plain carbon steels, having been carburized to the same extent, that is, having the same amount of carbon at equal depth, the alloy steels would be likely to have a finer grain, and therefore would appear to be deeper, whereas their carbon penetration would not be deeper.

CHAIRMAN d'ARCAMBAL: Would they not have a correspondingly finer grained core, too? Might not that compensate?

W. D. FULLER: I could not say as to that.

F. H. KINGDON: Without a doubt for rapid test, the single-quench is best, but there are a number of cases where the men do not agree on just what the depth of case is, where it is measured with a scale. We have found by heat tinting, that the case shows up very much stronger. To do this take your fractured specimen and place it in a gas flame, moving the specimen as uniformly as possible, watching the fractured surface until the case itself begins to show a light blue color, and the core a lighter color—by getting those colors you can measure closer with the scale.

H. E. ROSS: One of the speakers suggested that double the carbon of the core would be the criterion. A great part of the carburizing work today I think is with the low carbon steel, say 0.10 or 0.15 per cent carbon steel. I think the tendency is to decrease the carbon content of the core. If that were done, it would seem as if a 0.20 or 0.30 per cent carbon steel would be very little used for the ordinary purpose for which the case is made. I was wondering whether the speaker had in mind the alloy steels, or higher carbon cores, because if you are going to use that criterion for the ordinary low carbon steel, it would seem to indicate that you would have to revise very materially your ordinary standards of measurement. It seems to me that Society of Automotive Engineers 1020 steel with 0.15 to 0.25 per cent carbon is best for carburizing work. Steel should be low rather than high in carbon. A carbon content of 0.30 per cent is too high. Steel with a Society of Automotive Engineers' specification of 0.10 to 0.20 per cent carbon has given me best results for the plain carbon steels.

S. P. ROCKWELL: I had in mind simply the Society of Automotive Engineers' carburizing steels; not the higher carbons,—coming within the Society of Automotive Engineers' limits.

CHAIRMAN d'ARCAMBAL: I believe that you showed, Mr. Rockwell, that double quenching gave you a deeper case.

S. P. ROCKWELL: As a general rule, yes, due to carbon diffusion.

CHAIRMAN d'ARCAMBAL: That is a good tip for the men selling carburizing compounds.

Is there any further discussion?

B. F. WESTON: While I am not directly interested with carburizing, this subject is of great interest to me in view of some experiments I conducted some time ago on the comparison of the depth of carburizing between cold rolled and hot rolled steels of various compositions. I ran across, of course, the same difficulty that these men have stated, that is, the point at which the depth of penetration has taken place. It appears to me that unless there is a committee at work on this, there is no one thing that this section, or this Society could do that would be any more beneficial than to have a committee appointed to run this thing down, because apparently it is very difficult to get anywhere in comparisons, that is, between two methods, or between two men in the same shop, and as I stated, unless there is a committee appointed for this work, it seems to me we will not get very far in the solution of the problem.

CHAIRMAN d'ARCAMBAL. I believe—am I right, Mr. Allen—that Mr. Rockwell's paper is part of your subcommittee work on case hardening?

R. J. ALLEN: It started as such but after it had been carried along a certain way it was thought that more benefit would be obtained through discussion, if it were presented in the form of a paper at the convention. The material will be available for use on the standards committee next year, however.

PROF. O. W. ELLIS: Mr. Rockwell and I happened some little while ago to be called in together, unbeknown one to the other, to undertake an investigation of some steels, and to determine whether these steels had been properly case hardened or not. It so happened that we used the same method of determining the depth of case. That was using the microscope as a criterion.

Mention has been made of the difficulties of agreeing in the depth of case in certain instances, but Mr. Rockwell and I agreed within very small fractions as to the depth of case, using the microscope, although we had no idea at all that we were working along the same lines.

It appears from Mr. Rockwell's paper that the chief difficulty, so far as his experience is concerned, was that a certain depth of case was specified, but no method of testing that depth of case given. Would not the whole difficulty in this connection be overcome, at any rate to a very large extent, if when depth of case was specified the method by which the depth is to be measured were also specified?

CHAIRMAN d'ARCAMBAL: May I ask, in measuring case depth under the microscope, when you measure the hypoeuctectoid, do you measure the original carbon content of the core?

PROF. O. W. ELLIS: In this instance I went as close as I could to the core.

DR. C. M. JOHNSON: To reply to the last speaker, you are up against shop conditions, so that while two experts with a microscope might agree very nicely, the question is, how are you going to turn this method over to the shop? It would seem to me, as I said before, the simpler the better. If a committee can determine what the average greatest difference is between different practical observers, then let that be the tolerance or lee-way in the specification.

SYMPOSIUM ON METALLURGICAL EDUCATION HELD AT THE FIFTH ANNUAL CONVENTION OF THE SOCIETY, PITTSBURGH, OCTOBER, 1923

Continued from February TRANSACTIONS

A CONTRIBUTION TO THE SYMPOSIUM

By Frederick Crabtree

SO MUCH has been said and written about engineering education, by men competent to discuss the subject, that it would be quite improbable that one could really add anything new at this time. Interesting as was the discussion at the Detroit meeting, there was little real difference of opinion among those who took part. It was generally agreed that for the average student, even for the great majority of students, the course should not last longer than four years; that a thorough grounding in the fundamental studies—mathematics, physics, chemistry and mechanics, together with a fair command of good English, is by far the most important part of the course; and that a reasonable portion of the total time should be devoted to some subjects tending to broaden the students' viewpoint beyond the merely technical field, and to give a little insight into the human and commercial aspects of life. Every one agrees that for the exceptional student a more thorough advanced training in technical subjects and in research methods is desirable.

Industrial processes are becoming more complex and exacting every year, calling for greater refinements in methods and equipment. There are positions in industries based on scientific research, requiring men with special training which can hardly be given in a four year course. But the number of these specially trained scientific metallurgists required by the industries is small compared with the number urgently needed for production work along established lines. In other words, the art of metallurgy calls for many more men than does the science of metallurgy. So the metallurgical courses in technical schools are, with reason, arranged to supply this demand. The unusual student frequently gets the more thorough scientific training by taking post-graduate work.

The author is professor of metallurgy, Carnegie Institute of Technology, Pittsburgh.

Hugh Tiemann, in his remarks at the Detroit meeting, came very near expressing my interpretation of the industrial need when he said the essential points were—

Clear thinking, clear seeing, clear writing, clear speaking

My own phrasing has been, that the most important objects of engineering education was to develop the student's ability

(1) to see things understandingly
(2) to reason or think correctly and clearly
(3) to learn where and how to get needed information
(4) to express his ideas clearly

and in addition, to develop good mental and other habits, an open mind, and good character and sense of responsibility.

The ability of an engineer to see, and to interpret correctly what he sees, is based largely on sound training in physics, chemistry, mechanics, and other natural sciences, such as mineralogy, geology, etc.; but ability to see depends on the cultivation of the habit of observation and of thinking about what is seen. We are creatures of habit; and in nothing more so than in the practice of observing things. The faculty of seeing things, is capable of a high degree of cultivation.

Again, it is very easy to fall into slipshod, careless mental habits. Looseness of thought, neglect of a reasonable degree of accuracy or exactness, carelessness as to details, are serious faults in an engineer, therefore tendencies toward such habits should be combated in an engineering school, and the students encouraged to develop the habits of mental thoroughness and accuracy, of dependability.

It is evident that this interpretation of the objects of engineering education calls for something more than the selection of this or that subject for a curriculum. In fact, the method of teaching is often of greater importance than the choice of the subjects. It is true that the wisest selection of subjects brings the best results, if equal skill is used in the instruction in both cases; but the importance of the method of teaching must be remembered.

One of the factors which make the selection of a curriculum in metallurgy complicated, is the extreme diversity of types of work the student may desire to follow. He may

want to enter the metallurgical industry in the production, or works operating end; he may desire to remain in the purely technical, investigational, or advisory work; or he may wish to specialize in scientific research. In other words, he may wish to practice the art of metallurgy in any of its many branches, or he may prefer to apply himself to the science of metallurgy. The characteristics and preparation best suited for these two lines of work are sometimes quite different. A man may be very successful as a superintendent of an iron blast furnace plant, a copper smelter, a Bessemer or open-hearth steel works, a gray iron foundry, a brass works, a lead smelter, or an ore concentrating mill, but who would never be much of a success as a research student of the microscopical structure of metals or alloys. But these are only a few of the lines of work that metallurgical engineering students may go into. Modern industries are so complex, and bring into play so many branches of science and engineering, as well as employing large numbers of men, that executive officials require a range of knowledge that cannot be mastered in any college course. It must be acquired while the young man is making his industrial progress and the college course furnishes merely the foundation, valuable principally in that it has given him the ability to acquire what he needs.

In recent years the tendency has been to emphasize the training of men for the production work in the industries, and the continued demand for graduates indicates at least partial success. What criticisms are heard reflect more on the methods of training than on any characteristics of the curricula.

But while the principal demand will continue to be for men for the production type of work, the growing appreciation of the value of research work and the demand for highly trained specialists of the exceptional type, fitted for research, makes it important that instructors be always on the lookout for young men suited for such work, and encourage them to take advanced work in science and research methods. The demand for such men is growing rapidly, and the best methods of selecting and training them is one of the big problems in metallurgical education.

DISCUSSION OF METALLURGICAL EDUCATION

By Oscar E. Harder

THE writer was requested by the chairman of the program committee to write a formal discussion on the subject of "Metallurgical Education," to be presented at the annual meeting in Pittsburgh. At the annual meeting of the American Society for Steel Treating in October 1922, there was held a symposium on "Metallurgical Education." A number of papers were presented by men connected with educational institutions giving work in metallurgical education and, likewise, a number of papers were presented by men in the industries where men trained in metallurgical work are required. The idea of this group of papers obviously was to bring about a better understanding between the educational institutions and the industries, most likely with a view of readjusting, if necessary, the courses of study leading to the degree of metallurgical engineer or to degrees with special training in metallurgical engineering.

Some of the requirements of a metallurgical engineer were well stated by speakers from the industries. For example, J. M. Watson, metallurgist of the Hupp Motor Company, outlined very definitely his ideas of the requirements of a metallurgical engineer. He related the metallurgist to the following departments: engineering, purchasing, manufacturing, sales and service. It appears that his outline of requirements may be taken as representative of a metallurgical engineer for the automotive industry. Dr. John A. Mathews emphasized the importance of a liberal education as a foundation for professional studies and of thorough training in chemistry, physics, and mathematics as furnishing the broad principles underlying metallurgical training, and finally an acquirement of the "scientific method." Dr. Clemens discussed the same subject from the standpoint of a research organization connected with a big automotive industry.

In order to arrive at some definite conclusions as to whether our courses in metallurgical engineering are designed to meet the requirements outlined by these speakers, it ap-

---

A paper by Prof. O. E. Harder, University of Minnesota, presented by Prof. R. L. Dowdell.

peared that a survey should be made of educational institutions giving work leading to the degree of metallurgical engineer or to some other degree which includes special training in metallurgy. The catalogs of the following institutions were secured and a survey made of their courses of study leading to the respective degrees.

List of Educational Institutions

1. Armour Institute of Tech.
2. California Inst. of Tech.
3. Carnegie Inst. of Tech.
4. Case School of Applied Sci.
5. College of the City of N. Y.
6. Colorado School of Mines.
7. Columbia University.
8. Cornell University.
9. Kansas State University.
10. Massachusetts Inst. of Tech.
11. Ohio State University.
12. Princeton University.
13. Purdue University.
14. University of California.
15. University of Cincinnati.
16. University of Illinois.
17. University of Michigan.
18. University of Minnesota.
19. Univ. of New Hampshire.
20. Univ. of Pennsylvania.
21. Univ. of Pittsburgh.
22. University of Wisconsin.
23. Yale University.

Armour Institute of Technology gives a small amount of metallurgy in connection with courses in chemical engineering but does not list a degree of metallurgical engineer, nor does it give the degree of chemical engineer with special training in metallurgy.

California Institute of Technology does not confer the degree of metallurgical engineer and their work in metallurgy is limited to a course entitled "Metallurgy and Heat Treatment," which is given in the department of mechanical engineering.

Case School of Applied Science is included in the investigation. Their work is rather difficult to classify because of the large amount of work included in their summer courses or "practical courses." However, these have been evaluated as accurately as possible.

The College of the City of New York does not give any courses in metallurgy or metallography.

Columbia university could not be included in this investigation because their course of study is a 6-year program. It

involves a 3-year preliminary course and then a 3-year course which is strictly that of a metallurgical engineer.

Cornell university does not give the degree of metallurgical engineer and they give only a limited amount of work in metallurgy.

Princeton University does not give any courses in either metallurgy or metallography.

The University of Cincinnati has a co-operative course and values of the different subjects could not be determined.

The University of New Hampshire and the University of Pennsylvania do not give the degree of metallurgical engineer and the University of New Hampshire does not give any courses in metallurgy.

The University of Pittsburgh, which is included in this survey, gives the degree of metallurgical engineer (a) general engineering and (b) metallurgy of iron and steel.

The University of Wisconsin could not be included in the investigation because of their extensive system of electives.

In a survey of this character, probably no method of evaluating the different courses could be found which would be entirely free from criticism. In this particular survey the basis has been 216 units of credit for graduation. This gives 54 credits per year which amounts to 18 credits per quarter or 27 credits per semester. The further assumption has been made that the unit of credit represents 3 hours work on the part of the student. All lecture periods have been assumed to represent a unit of credit and to require 2 hours additional work on the part of the student, thus taking a total of 3 hours of the student's time. Laboratory courses have been assumed to represent one unit of credit for each three hours work. While this method of calculation may have introduced some discrepancies, it is considered that the results of the final survey in which the instruction in any school is grouped under certain headings and calculated to a percentage basis are reasonably reliable and may be taken as indicating the distribution of the work in that institution. The method of determining the percentage of credit has been to calculate the credits to this uniform basis mentioned above and then

Table I

Distribution of Work in Courses of Study Leading to the Degree of Metallurgical Engineer, or Other Engineering Degrees with Options in Metallurgy.

Courses of Study	Carnegie Inst. of Tech. 1922-23.	Carnegie Inst. of Tech. 1923-24.	Case School of Applied Science.	Colorado School of Mines.	Massachusetts Inst. of Technology.	Ohio State Univ.	Purdue University.	University of California.	University of Illinois.	University of Kansas.	University of Michigan.	University of Minnesota.	University of Nevada.	University of Pittsburgh (a).	University of Pittsburgh (b).	Yale University.	Average Per Cent of Each Subject.
Biology							1.10									4.29	0.34
Chemistry	13.84	12.15	11.87	14.38	16.94	6.26	29.44	13.30	13.75	20.52	32.14	6.86	9.72	13.37	16.20	18.85	15.59
Civil Eng.						2.32											0.14
Drawing	1.68	3.83	4.61	8.55	3.04	6.39	3.81	1.97	5.63	4.48	5.71	5.61	3.47	2.61	2.61		4.00
Economics	4.61	8.17	1.10		4.69		3.85			2.08	2.14		1.39	4.27	5.29	4.69	2.64
Electives	2.72	2.03		25.00	1.05	4.25		7.10					5.56			18.82	4.16
Elec. Eng.	3.45	4.15	3.99		3.83	2.32	5.17	2.08	1.97	2.08	2.86	1.54	2.08	3.33	3.09		2.62
English	4.37	3.83	4.93	3.81	4.00	3.75	5.51		4.23	5.43	4.29		4.17	9.12	9.12	4.29	4.43
General Eng.						0.83											0.05
Geology	6.51	7.76	6.55	7.89	2.33	8.15	1.81	11.44	4.17	7.36		10.19	12.47	6.35	5.26	4.40	6.41
History		3.84	0.30		4.00		1.66									4.29	0.88
Ind. Eng. and Administration	2.38	2.30					1.91			1.97							0.53
Mathematics	10.96	9.18	9.98	8.56	9.00	12.85	11.94	8.24	12.60	11.33	11.43	11.39	11.11	11.54	11.46	6.55	10.51
Mech. Eng., Mine & Met. Plant	5.13	4.79	3.82	1.32	6.48	6.13	1.31		5.74	2.81		4.84	4.06	1.63	1.70		3.14
Mechanics	5.47	6.80	6.13	2.50	6.08	9.26	7.82	10.42	9.27	9.79	10.00	7.84	8.24	5.57	5.16	7.83	7.39
Metallurgy	8.75	12.66	12.22	10.00	15.24	15.58	3.89	13.32	7.31	9.02	7.14	24.50	11.20	23.85	25.48	11.04	13.20
Met. Metallography	1.24	1.62	5.50	4.05	1.73	5.09		1.40	1.56	1.97	2.86	6.94			4.23	3.75	2.62
Met., Ore Test. & Ore Dressing	1.36	3.66	2.21	5.63	1.39	3.70		2.80	6.52	3.37		6.39	2.78	3.57		2.03	2.84
Mining			2.83	3.81	1.04			9.15	4.84			3.02	7.07	4.44			2.26
Modern Lang. & Cult. Electives	6.25		6.30				7.16		9.87	7.05	11.43						3.00
Phys. Ed., Hyg. & Military Sci.	12.62	3.33	2.42		3.71	4.21	3.98	6.25	4.21				1.39	2.61	2.61		2.96
Physics	6.39	7.46	6.55	7.89	10.04	6.59	6.25	8.24	6.25	7.25	7.14	3.62	9.72	5.17	5.17	10.17	7.12
Shop Practice, Found. and Forge	2.27	2.55			1.23		2.50			2.78	1.43			1.31	1.31		0.96
Surveying			7.27	0.66		2.32	0.39	4.29	2.08		1.43	7.26	5.57	1.31	1.31		2.12
Tech. Reports			1.42		4.18					0.71							0.39

determine the percentage which the number of credits in that particular subject is of the total 216 credits. The results of that calculation are shown in Table I. Of the 15 schools included in this survey, 11 give the degree of metallurgical engineer and of the others Kansas State university, Purdue university, University of Michigan give the degree of chemical engineer with options in metallurgy and the University of Nevada gives the degree of mining engineer with options in metallurgy.

A study of the data collected in Table I shows a number of interesting results. In the last column of this table the average for all of the institutions is given. These values were obtained by taking the total per cents of the given subject and dividing it by 16, the number of different courses included in the survey. Two different courses of study from Carnegie Institute of Technology were included because a study of these courses will show what that institution did recently to revise their course of study. History is the only course added. Modern languages and cultural electives were dropped. The other changes are a matter of the percentages given different subjects, one of the most noticeable being increases in the economics and the marked decreases in physical education and military science.

At this time I want to point out that the subject of metallography is not included in the courses given in Purdue university, University of Nevada, University of Pittsburgh, (a) general metallurgy, and that the average of all these institutions, is only 2.62 per cent. If we consider only those institutions which give the degree of metallurgical engineer, and we use only the 1923-24 course of study for Carnegie Institute of Technology, that value is increased to 3.26 per cent.

In Figs. 1a and 1b the variations of these different courses of study in the different schools are shown in graphic form. The average for all of these schools is also given. It is not the intention of the writer to discuss the general merits of the courses of study given in these different schools, but to pay special attention to the amount of metallography included in the various programs.

Some idea of the development of the work in metallogra-

phy may be obtained from a study of Fig. 2. The data for this sketch were taken from Sauveur's text in metallography and represent the best information known to the writer. Since the last figure included in his survey was 1918, the increase in the number of laboratories since that date is not

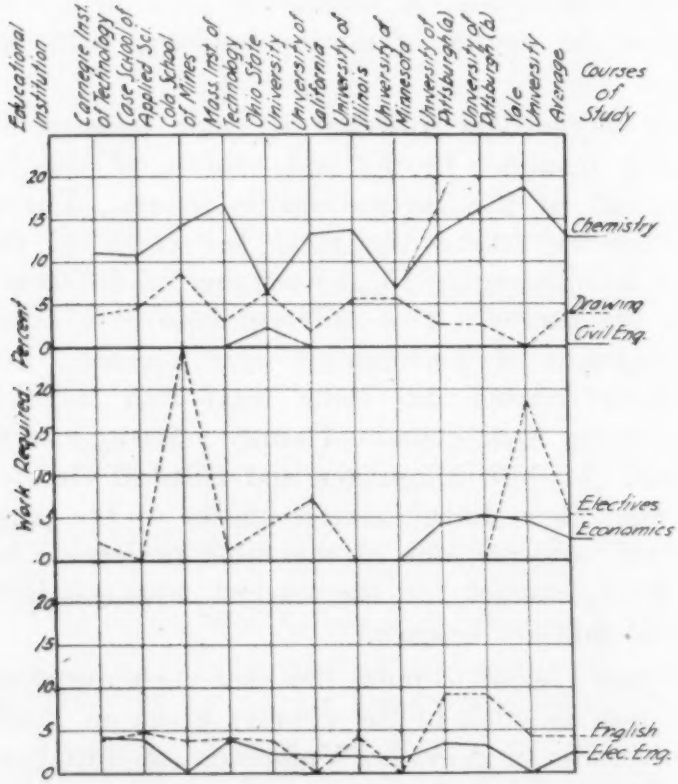


Fig. 1—Curves showing the distribution of work in courses of study leading to the degree of metallurgical engineer in the various colleges and universities.

known and the method used in this figure is simply to extend the line from the values 1916 and 1918. This would indicate at the present time that we have nearly 2500 metallographic laboratories in the United States.

It is interesting to consider the personnel of these laboratories. I venture to say that if you will pay attention to the men in charge of these laboratories you will find that in many instances they have not been trained as metallurgical engineers. The men doing this kind of work are chemists, mechanical engineers, shop foremen, etc. What I wish to em-

phasize is that the development of the subject of metallography in the industries is far ahead of the development of that subject in our educational institutions.

That subject has developed to such importance that it should be given due recognition in our schools and men given

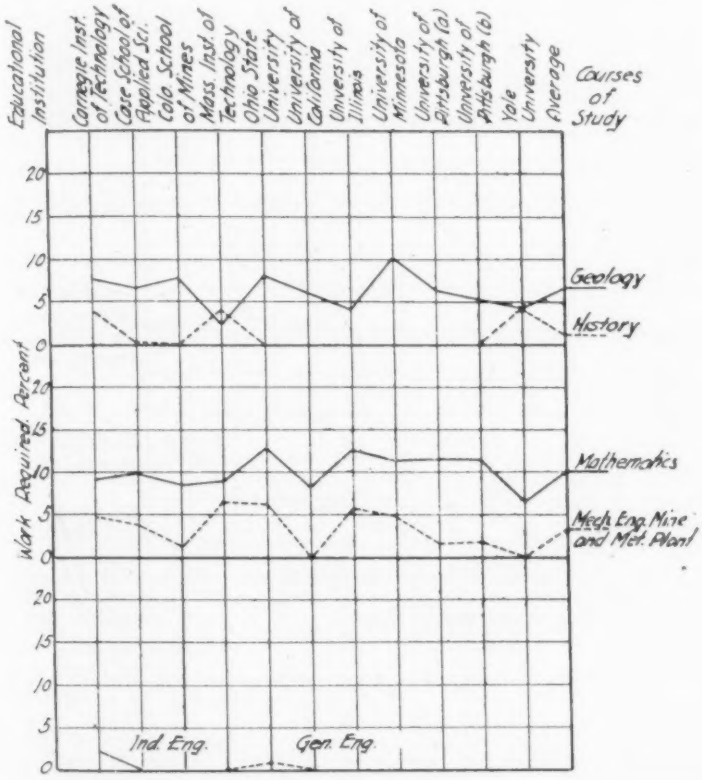


Fig. 1a—Curves showing the distribution of work in courses of study leading to the degree of metallurgical engineer in the various colleges and universities.

an opportunity to specialize, at least to some extent, in the field of metallography. Our courses in metallurgical engineering, as is generally understood, are still under the influence of the time when a man who took metallurgical engineering, might later take a position as a mining engineer, a geological engineer, a civil engineer, or possibly several other lines of work. Likewise the mining engineer not infrequently found himself in the position of metallurgical engineer. As a result, we find in our courses of study, large percentages of our time given to geology, metallurgy, ore testing, ore dressing, mining, and surveying.

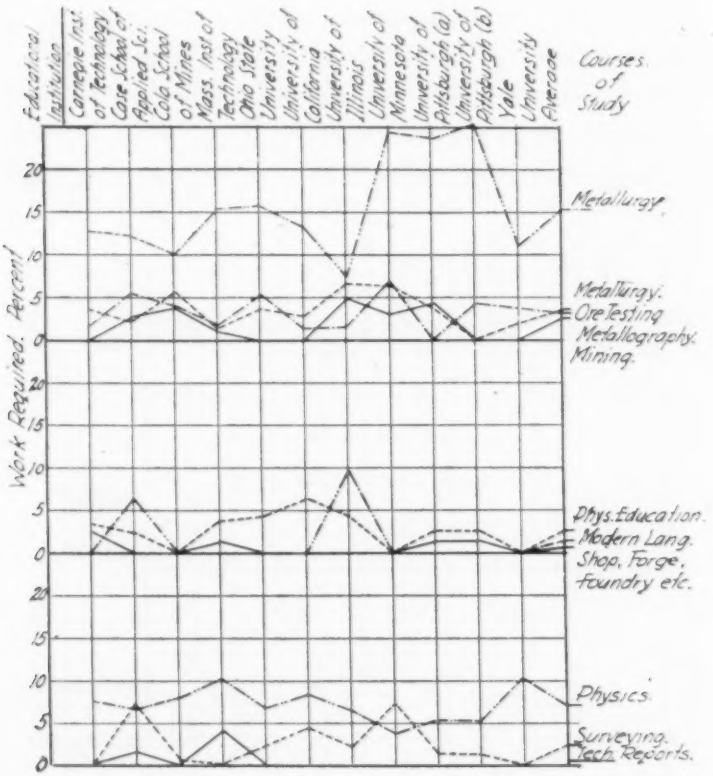


Fig. 1b—Curves showing the distribution of work in courses of study leading to the degree of metallurgical engineer in the various colleges and universities.

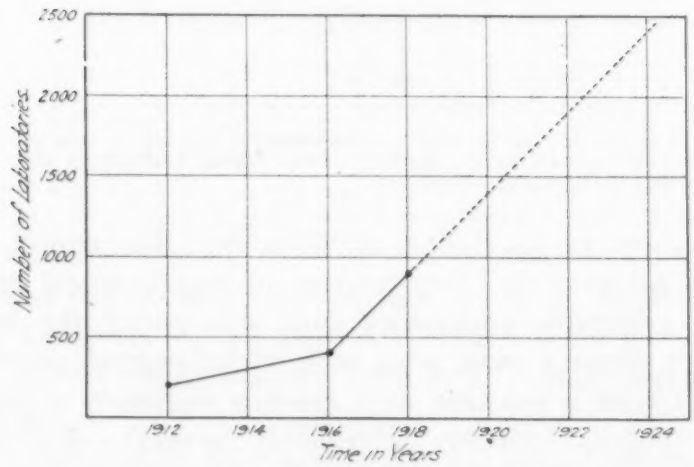


Fig. 2—Curve showing the increase in the number of metallurgical laboratories in the United States from 1912 to 1924.

I do not believe that there is any one of the courses of study included in Table I, which can be considered as ideal with reference to special training in metallography. In other

words, I believe the course of study is yet to be outlined and developed which will take the proper recognition of all the requirements for the man especially trained in the field of metallography so that he will have the fundamental training in chemistry, physics, mathematics, metallurgy, economics, industrial engineering or administration, and possibly a number of other subjects, to make a well rounded course.

It is hoped that the writer will not be misunderstood in his intention when he includes Table II giving the courses in metallography given in the School of Mines of the University of Minnesota. These have been included with a view

Table II

Courses in Metallography Given At The University of Minnesota.

No.	Title	Lec. or Rec. Hrs.	Lab. Hrs.	Required of	Prerequisite Courses
150f	Mphy. for Elec. Eng.	2	3	Elective	....
151w	Adv. Mphy. for Elec. Eng.	2	3	Elective	150f
153f	Mphy. for Met. Eng.	3	4	Jr. Met. E.	Chem. 28w, Phys. 43
154w	Mphy. for Met. Eng.	3	4	Jr. Met. E.	153f
155s	Mphy. for Met. Eng.	3	4	Jr. Met. E.	154w
156f	Mphy. for Mech. Eng.	2	3	Elective	....
157w	Mphy. for Mech. Eng.	2	3	Elective	156f
159s	Dental Metallography	1	2	Jr. Dents.	Chem. 21-22
160f	Mphy. for Chemists	2	3	Elective	Chem. 20
161w	Adv. Mphy. for Chemists	2	3	Elective	160f
162s	Adv. Mphy. for Chemists	2	3	Elective	160f
163f	Adv. Metallography	To be ar.		Elective	155, 151, 157, or equiv.
164w	Adv. Metallography	To be ar.		Elective	155, 151, 157, or equiv.
165s	Adv. Metallography	To be ar.		Elective	155, 151, 157, or equiv.
201f	Adv. Mphy. for Graduate Students	To be ar.		Elective	....
202w	Adv. Mphy. for Grad. St.	To be ar.		Elective	....
203s	Adv. Mphy. for Grad. St.	To be ar.		Elective	....

to interesting educational institutions in additional fields of instruction in metallography. You will note from this table that metallography is required of only two groups of students, juniors in the College of Dentistry and the junior metallurgical engineers. The juniors in the College of Dentistry take only a 2-hour course for one quarter and during the past three years we have had approximately one hundred students in this course each year. At the present time our largest enroll-

ment in the elective group comes from the department of mechanical engineering where practically the entire senior class has elected to take work in metallography. At the present time they are taking in quite large numbers, the two beginning courses in metallography and quite frequently these students elect more advanced courses and in some cases choose to take a minor or even to do a thesis in metallography.

In connection with the work in metallography, we have developed a scheme of outlining the work for the entire quarter with definite assignments for reference reading and laboratory work. It is the writer's intention to submit one of these courses of study to the editor of the TRANSACTIONS of the American Society for Steel Treating for publication in the near future, with the hope that it may be of some assistance to others who are planning their work in metallography.

In conclusion, it is hoped that this discussion will increase the interest of our educational institutions in the rapidly growing subject of metallography, and that our courses of study will take recognition of the importance of the subject, revise some of our programs so that they will give first, a good fundamental training in the scientific principles, and then at least a reasonable amount of technical training in this rapidly developing subject.

CHAIRMAN GOODALE: Gentlemen, the papers are now open for general discussion.

PROF. D. F. McFARLAND: The point that Mr. Crockett brought out with regard to specific application of mathematics and various other subjects in the students' work, seems to me to be especially applicable to physical chemistry. As the average teacher of physical chemistry presents the subject, it is uninteresting, at least that has been the impression in my mind, as it is highly mathematical and highly theoretical. The average teacher of physical chemistry either does not know enough about its applications, or else does not care enough, to point them out, thus giving the average student the idea that physical chemistry is a terrible bore, and the sooner out of the way the better.

I wish we could in some way train physical chemistry teachers to bring out the commercial applications, or at least to point out how the laws which they develop mathematically can be applied. That does not at all relieve the rest of us from pointing out those industrial applications whenever the occasion presents itself. I hope that we can

in some way get the teachers who give the first courses in physical chemistry to give something of its applications.

PROF. C. UPTHEGROVE: We might possibly work in the same way that certain electrical engineering departments have, in regard to physics, rather than chemistry. Feeling that they were not getting the applications worked out in the way they wished them, they established certain courses in electrical engineering, which were primarily courses in physics, and took care of their problem in that way.

PROF. D. J. DEMOREST: We have done the same thing in several cases. That last statement is becoming quite a common thing, and I am wondering just what is the trouble with the apparent lack of contact between the engineering teachers and the teachers of the more fundamental subjects. It is a very common thing to camouflage what would ordinarily be a fundamental subject under the title of an advanced subject, and use that advanced subject as a course in chemistry of some kind, or physical chemistry.

We have in our metallurgical department a course in metallurgy given by our professor of mineralogy called "Thermal Chemistry of Minerals," and it is a fine course, it is just pure physical chemistry, but it is given by a man who appreciates what we want.

And then again I think that the teachers of the advanced courses have in some cases under-appreciated the necessity of repeating and reiterating fundamentals just about as badly as the teachers of the fundamental courses have not appreciated the necessity of emphasizing the application. I am much interested in what Mr. Crockett has said, because I agree with him absolutely, that unless a student gets some sensible connotation in his mind whenever any abstract law is being talked about he gets very little out of it.

Even in teaching the chemistry of fuels and gases I point out to my students, that if you do not get a picture of some kind in respect to the reactions going on in this procedure, they do not get its full meaning. I even go to the trouble of drawing on the board the electronic arrangement of electrons, in an atom of oxygen, to show how those atoms get mixed up with hydrogen atoms to form the water molecule; anything to get a picture in their minds.

This is where we fall down. We think that a reaction on the board or a formula in the book means something permanent in the student's mind, but it does not. I once had occasion to employ 200 or 300 chemists, chemical engineers, and physicists from all over the country, and I was quite astounded to note that a group of boys coming from one particular school, were almost of no use to me. They were just jammed full of formulas, but did not know what a single formula meant. The formulas were not connected up in their minds with a visualization of any kind.

PROF. C. UPTHEGROVE: In reference to Professor Harder's

Table I, I wish to point out that in the space for electives, under University of Michigan, none are shown though we actually have about eight per cent.

PROF. R. L. DOWDELL: In that case when he worked out the program for the University of Michigan undoubtedly he put that under something else, classified as mathematics, or something else.

PROF. C. UPTHEGROVE: I imagine the same thing is the trouble with the chemistry.

PROF. D. J. DEMOREST: At Ohio State university, in our class in metallurgy we have a class in our senior year called "Metallurgical Investigations." The student who is particularly interested in ore dressing goes into that. The student who is particularly interested in gas engineering goes into line, and then there is always a considerable portion of them who are particularly interested in metallography and they go into line. These of course would not show in Table I.

PROF. C. UPTHEGROVE: We have the same thing.

DISCUSSION OF FRENCH AND STRAUSS PAPER ENTITLED "EFFECT OF HEAT TREATMENT ON LATHE TOOL PERFORMANCE AND SOME OTHER PROPERTIES OF HIGH-SPEED STEELS," PRESENTED BEFORE THE FIFTH ANNUAL CONVENTION OF THE SOCIETY, PITTSBURGH

PAPER PUBLISHED IN SEPTEMBER, 1923 TRANSACTIONS

CHAIRMAN H. M. BOYLSTON: Gentlemen, one of the principal reasons for having these papers read at these open meetings is to provoke discussion, either verbally or written, and especially, of course, verbal discussion. You are going to have all the time we can possibly find for you to discuss these papers, even if we have to shorten the time we give to the author of the paper in presenting it.

The meeting is now open for discussion, and I hope you will not hesitate.

A. H. d'ARCAMBAL: I would like to congratulate the authors on this paper. I believe it to be one of the finest that has been written since the time of Taylor and White, and represents a tremendous amount of work.

Mr. French has stressed in his paper that these different treatments apply only to lathe tools. Now I believe that a large number of the men in this room harden not only lathe tools but cutters, end mills, reamers, and similar tools, and I am going to try to point out in a few minutes time the reason that these treatments do not apply entirely to such classes of tools.

First, I would like to ask Mr. French whether the time in the high temperature furnace was sufficient to bring the tools to the furnace temperature.

H. J. FRENCH: That is a pretty hard question to answer, but from our knowledge of the effect of mass action, we would say yes. We made preliminary experiments in order to determine what we believed was a desirable time, basing our judgment on the performance of the tools as well as the condition of the surface, (so-called "sweating"). It is, of course impossible to say whether the tool was at the high heat temperature throughout its entire section.

Recently there has been suggested a long-time high temperature treatment in which air is almost entirely excluded from the sample at the high heat. On account of the brittleness produced on long exposures, I do not know whether such a procedure is desirable. Whether our tools were entirely up at a high heat or not I could not say. The furnace used was of comparatively large thermal capacity, and the samples pretty small, ¼ by ½-inch sections, and particularly when they were preheated at 1600 for 20 minutes, I would say the tools were pretty nearly up to the high heat temperature, at least at the working portions.

A. H. d'ARCAMBAL: We found in using the 14.0 per cent tungsten, 2.0 per cent vanadium type of steel, that if a temperature greater than 2300 degrees Fahr. is attained, that is, temperature of the tool, a coarse fracture, with corresponding brittleness was obtained. In other words, if a milling cutter was made from this type of steel, and was heated to 2350 degrees Fahr., the tool would stand only very short service, because of the chipping of the edges, due to the very coarse fracture. A temperature of 2400 degrees Fahr. for the 18.0 per cent tungsten type, is not too high, but it is a little higher than is usually used in practice. When I am speaking of these temperatures I mean the temperature of the tool before it is quenched and not the furnace temperature. Moreover, I noticed that the authors preheated their tools 20 minutes after they reached the preheating temperature. That practice is also not commercially used for hardening tools where minimum scaling is desired. The tools are usually placed in the preheating furnace, and as soon as they have attained the furnace temperature, are removed to the high heat chamber, in that way minimizing scaling. If scaling is produced at the 1500 or 1600 degrees Fahr. preheat, and the tool is carried over to the high heat, quite often decarburization is produced.

I also noticed that no difference in cutting efficiency was found between tools not drawn and tools given drawing temperatures up to 1100 degrees Fahr. That also might apply to lathe tools, although it is not always the case, but certainly does not apply to tools where brittleness is a factor. I believe that the author's paper showed that some of the tools not drawn, broke after short service. If these cases were averaged a much lower figure would be obtained than with tools given the high draw.

We were pleased to note that tools quenched into a lead bath at 1100 degrees Fahr. and not drawn, were just as brittle as tools quenched in oil. That is another good proof that tools cannot be quenched and drawn in the same operation.

Moreover, from some of these tables it would appear advisable not to preheat tools, because of the minimum distortion occurring on tools not preheated and also in some cases because of greater cutting efficiency, but hardening without preheating is dangerous practice on most types of high-speed tools.

H. J. FRENCH: We are appreciative of Mr. d'Arcambal's comments, and to give you an idea of the amount of work involved, we cut up over sixteen tons of metal in this investigation during the past year.

With respect to preheating practice mentioned by Mr. d'Arcambal, we appreciate that commercially preheating is not carried out under the time-temperature control that we used, but from an experimental standpoint when we are considering and trying to find out the effect of, we might say, unknown variables, it is absolutely

essential, or was at the start, to accurately control the manner of preheating including particularly the time of preheating. Now we do not necessarily recommend in any particular case the preheating practice used in our tests. It was shown that the manner of preheating had a very minor effect upon the tool endurance, that is, within the range 1400 to 1700 degrees Fahr. or a slightly greater temperature range. However, in order to eliminate all variables possible and to arrive at correct results it was necessary to control the preheating practice in these tests in the manner described.

Now with respect to the tempering of these tools; we are dealing with a specific type of service, and there is always danger that the results are to be interpreted for general shop conditions. I would like to caution you in that respect.

The brittleness of the tools treated in the lead bath, according to our opinion, was greater than that attained in the oil hardened samples. As a matter of fact, our oil hardened samples which broke, show a fair degree of toughness compared to the samples which were quenched in lead. The former lasted a few seconds in the lathe whereas the latter broke as soon as the feed was thrown in. They were extremely brittle. That, I believe, is largely due to the very rapid rate of cooling in the lead bath as compared with the rate of cooling in oil.

A. E. BELLIS: I am very much interested in Mr. French's data on the effect of time of the high heat. Mr. French shows an increase of endurance of 100 per cent by doubling the time. I would like to ask Mr. French the question, would it not be logical to try to increase the performance ten times by leaving the piece in the heat ten times as long?

H. J. FRENCH: To what curves or set of results are you referring?

A. E. BELLIS: I have noted that your figures show that some pieces left in 50 seconds, as against some pieces left in for a minute and a half, gave an increased performance of 100 per cent for the longer time.

H. J. FRENCH: The answer to that may be divided into two sections. We don't know whether the endurance time at high heat curve, is nearly a straight line under time conditions encountered under ordinary heat treatment practice or whether it turns off at a given time in the high heat furnace when the structural changes are, we might say, almost complete, so that a given increment of time thereafter would cause no noticeable change.

There is also a limit to the time in the high heat furnace from the standpoint of oxidation and decarburization. In the case of our lathe tools, that was a minor factor, because the test was so conducted that after heat treatment the nose of the tool was ground down well below the skin. Nevertheless, the skin effect due to de-

carburization and oxidation must be considered and makes long exposures undesirable. That is even more important than the first point mentioned.

A. H. d'ARCAMBAL: I would answer Major Bellis' question by saying that tools in the high heat chamber, say for three-quarters of a minute, were removed at too low a temperature, whereas, the tools given a minute and a half attained the proper heat. Tools, however, should not be soaked at the furnace temperature, for such treatment coarsens the grain. That is why some of the pack hardening methods fail. You obtain a very brittle, coarse material due to soaking. The quicker the steel can be brought up to temperature, the greater the cutting efficiency.

H. J. FRENCH: The longer the time, the greater the grain growth and the more brittle the material will be.

A. E. BELLIS: I have seen tests where the soaking has been 100 per cent of the time in the furnace. Where the time was increased 100 per cent beyond that necessary to get it to temperature, increased the efficiency of a tool. It is possible to leave a piece in a bath at the proper high heat twice as long as necessary to bring it to heat, with increase of efficiency, though this effect varies with composition of the tool, kind of work it is used on and other factors.

H. J. FRENCH: As shown by our results, the reactions that are brought about by the high heat temperatures are rather sluggish, and time must be given for their completion, or at least, the progress of those reactions. If you do not give enough time for those reactions to take place, you get endurance that is characteristic of a lower temperature. Again, if you heat in such a manner that you get entirely a skin hardening and grind down in such a manner that the working portion of the tool is not in the zone of the high temperature, you will not get the characteristic performance.

A. E. BELLIS: That means you have not a uniform structure through the thickness of the tool.

H. J. FRENCH: In such cases, yes.

JEROME STRAUSS: You must also consider that the time necessary to reach a peak on the time-endurance curve will be largely dependent upon the temperature of the hardening operation and will be markedly different for hardening conducted at 2400 degrees Fahr. than if, say, 2250 degrees Fahr. were used, as is common practice in a great many plants.

H. J. FRENCH: It will also depend upon the relative thermal capacity of the tools being heated, and the furnace. The time required for a 1-inch by ½-inch tool in a furnace 4 x 4 x 4 will be entirely different than when heating the same size sample in a furnace 12 x 8 x 12, other factors being constant.

A. E. BELLIS: I can not resist the temptation to call attention to the fact that if you had a liquid as your heating medium,

the time of heating the tool can be increased without injuring the tool, and the specific heat of the furnace, or the amount of heat available to flow into the tool rapidly, can be greatly increased, and the control of the temperature can be maintained very much more effectively than heating in an oven type of furnace.

H. J. FRENCH: These tests as originally stated in the report, show the extreme importance of the time factor in the hardening of high-speed steel tools. We are not, except in one case, attempting to determine the best media or the best equipment for hardening high-speed steels. We are interested in the time-temperature relations in heat treatment from the standpoint of performance of lathe tools and dimensional changes in hardening.

HYMAN BORNSTEIN: I should like to ask whether or not you have observed any difference in distortion in the manner of cooling, that is, on quenching in oil or cooling in air.

H. J. FRENCH: In answer to that, I might say we have made some tests on air cooling versus the oil quenching, and there were differences in the dimensional changes, but we were not satisfied with the results we obtained and did not include them in this report. I do not think I am prepared to say exactly what the variations are, but there are differences. As shown in that table where distortion was figured out, you obtain an indication that both the manner of heating and the manner of cooling are of importance, and that, of course, is true in all cases, whether it be high-speed steel or ordinary carbon steel. It is the complete cycle that counts, and whether a particular variable in that cycle is of controlling importance depends entirely upon the specific conditions with which you are dealing. I do not believe our knowledge today is such as to allow us to predict what will happen under specific conditions. The entire series of variables and the importance of each one depends upon the specific condition under which you operate.

HYMAN BORNSTEIN: Would you, from the results that you obtained, say that air cooling is conducive to less shrinkage than oil cooling?

H. J. FRENCH: In our preliminary tests we found a greater expansion on air cooling than on the oil quenching; that is as we might expect from a structural transformation standpoint.

MR. CONRAD: I would like to ask the speaker if he took the shape of the tool into account.

H. J. FRENCH: What do you mean by that?

MR. CONRAD: If I remember rightly, you said in your paper you had a 6 degree back slope on your tool. Why did you take that?

H. J. FRENCH: I don't remember whether it was 6 or 8 degrees, but we took the same tool form as we had in our previous tests, and that tool form was chosen because it had been used in

a large number of competitive tests. In other words, in our first paper we were considering the breakdown test in the form that it had been used commercially for a number of years at one large manufacturing plant. In this present one, which supplements the first paper, we chose the same tool angles. That is the only reason for the choice made. The tools approximate, I believe, a Sellers No. 30 tool in most respects.

MR. CONRAD: It has been my experience with as small a top break as 8 degrees, that the chip is likely to break close to the edge. In the new design of milling cutters we have a big undercut, probably 15 or 20 degrees, getting the chip to break farther back on the tool, because the wear is along the edge and tends to feather it.

H. J. FRENCH: I would call attention to the picture shown in our previous report. Ribbons of steel about 300 feet long were obtained from many of our tools, providing the metal coming off at the start of the test was properly supported. The ribbon tends to break by its own dead weight, but if properly supported at a distance from the lathe and allowed to reach the ground gradually at the start of the test, the ribbons which were obtained were sometimes as long as 300 feet. As the test progresses and the tool "gutters" and the nose wears away, the chips break off shorter and shorter.

FRANK GARRATT: I would like to ask Mr. French if they were able to produce the flaky fracture to which they referred by any method other than the double quench without an intervening anneal. I understand considerable work has been done in attempting to produce this type of fracture.

H. J. FRENCH: We were only concerned in the production of "flaky" fractures in heat treatment. We have, however, as I have said before, observed them under other conditions, but we have not investigated other causes.

A. E. BELLIS: I think the point that has been brought up of the more brittle tools in quenching at 1100 degrees Fahr. is more or less contrary to the general experience along that line. I would like to suggest that the rate of cooling which Mr. French believes was responsible for that brittleness could have been decreased very much if he had raised the temperature of his lead.

JEROME STRAUSS: I believe that Mr. Bellis' statement deserves much consideration, and I would like also to refer to the statement that Mr. d'Arcambal made earlier in this discussion. I feel that it should not be recorded, without objection, that quenching into a liquid medium at the temperature of the draw, without subsequent drawing, is not of any value. I don't believe that is necessarily true, but rather that it is dependent entirely upon the rate of cooling. In other words, raising the temperature of the lead, or using some other medium that did not cool the tool as rapidly as

lead, might have had an entirely different effect upon these tools.

A. E. BELLIS: Mr. d'Arcambal brought up a very interesting point, that only a very small percentage of the high-speed steel that is in commercial use today gets the drastic performance of having to work at a temperature of 1400 degrees Fahr., as I believe these tests were run. It is just a matter of common sense and logic that you need different conditions with respect to heat treatment and composition of the steel for such tools from what you need where you have a tool of the nature of a twist drill or a threading tool. I think this point should be brought out because I have seen a great many metallurgists fall down on high-speed problems by trying to treat a finishing tool as though it were a hogging tool.

H. J. FRENCH: We agree with Major Bellis entirely. In fact, I emphasized previously, that generalities were not in order. The severe conditions in these tests apply to a particular type of service, and we might say, approximate a problem which we had in view. There is no justification, however, for saying that the effects which we obtained hold good when taking a finishing cut, for example, nor do they necessarily hold with other types of tools. For example, in this paper there is given a discussion of some of the heat treatment characteristics of the four types of steels, and in that discussion attention is called to some of the limitations of each type. To repeat what is in the paper, the high tungsten-cobalt steels require excessively high temperatures for maximum endurance; likewise, the low tungsten-cobalt steels require somewhat higher temperatures than the low tungsten-high vanadium steels. Now the choice of a given tool depends on a number of factors besides the endurance, and you will find in the report, a discussion of some of these. Of course, in any case the choice depends upon the service for which the tool is intended, and that varies not only for a given type of cutting, but in given shops, so I would like to emphasize again what Mr. Bellis has said, and call your attention to the fact that this is clearly indicated in the report.

HYMAN BORNSTEIN: Mr. Chairman, I have heard a lot here about length of time of preheating, about the length of time of soaking at the high temperature, but I have not heard anything about the length of time of drawing. I should like to know whether Mr. French has any information on the characteristics obtained by a short length of time of drawing or by a longer length of time.

H. J. FRENCH: No, we have made no tests covering the time at the drawing heat. The time we chose was, I believe, sufficient to allow reversal of the hardening change. It was fixed in each case and as the tools were all of the same size, no variable was introduced. I don't know what the effect would be on the performance if we increased the time at 1100, for example, from 30 minutes to four hours. As a matter of fact, if there are any changes at all they

would follow the same order and type of changes which we would get from other types of steel. Whether or not it is possible to ruin the tool by soaking for four hours or so in place of time sufficient to allow the tool to reach the temperature and stay there long enough to complete any changes, I don't know.

HYMAN BORNSTEIN: My question was directed mainly to ascertain whether a 30-minute draw would be better than a 15-minute draw. It wasn't an ultimate test, such as the very long period you mentioned.

H. J. FRENCH: That would depend again upon the relation of the thermal capacity of the furnace and the samples and the manner of heating. In some cases 15 minutes might be ample and you would find no difference from that and thirty minutes. In other cases you might find a difference because of not having reached the desired temperature in fifteen minutes.

DISCUSSION FOLLOWING H. S. GEORGE'S PAPER ENTITLED "CONICAL ILLUMINATION" PRESENTED BEFORE THE FIFTH ANNUAL CONVENTION OF THE SOCIETY, PITTSBURGH

PAPER PUBLISHED IN AUGUST, 1923 TRANSACTIONS

CHAIRMAN P. D. MERICA: Gentlemen, Mr. George's paper is open for discussion.

H. M. BOYLSTON: I think Mr. George is very much to be congratulated in bringing before us this new tool for further microscopic research. I do not believe that he intends to imply that this method of illumination should replace other methods, it is simply an additional tool, as I understand it. I think in connection with high-power work, especially, it is going to be very useful. I hope that it will be made available on the market in some way so that each of you will not have to go through the same experimental difficulties. I do not know whether any steps have been taken toward that end or not.

H. S. GEORGE: I do not know. I think Bausch and Lomb have tried to do a little work, but their new machine, so far as I can see, does not admit of the same use of the spot. The new machine employs a band of light, and I doubt if they would be able to get the same results.

H. M. BOYLSTON: Have you compared your results with the results obtained from the mirror illuminator that Bausch and Lomb had on the market? You get a type of oblique illumination with that apparatus.

H. S. GEORGE: No, I have not. I wanted to do that, but I did not have the proper equipment to use, so I can not say what the results would be.

T. D. LYNCH: I want to congratulate Mr. George on this very valuable paper, which, to my mind, is going to unearth a number of things that we have had as questions in our mind about photomicrography. This will give us a better analysis of some of those things than we have had heretofore. I feel it is going to be an instrument in the development of research work that will help us, and that we will use. I want to thank him for bringing such a paper before us.

L. V. FOSTER: May I ask Mr. George if these pictures were made with the central stop diaphragm or all made with the iris diaphragm, which is eccentric with the central illumination?

H. S. GEORGE: They were made with the spot placed to one side of the center, in such a manner that it cuts out the majority of the rays from one side and allows a preponderance of rays from one direction.

L. V. FOSTER: It seems to me you really have the same illumination you would get with a prism illuminator, or with the silver reflector, which is semicircular, except that the prism illuminator and the silver

reflector are much harder to manipulate with the high-power objective.

H. S. GEORGE: I think you would get the same results, although I have not tried it. I do not see why you would not. Perhaps you would not get so much illumination.

W. J. MERTEN: I am wondering what the speaker would say about relief polishing and deep etching and its effect under this conical illumination. In connection with the Bausch and Lomb microscope, I believe the method to be used there, would be simply to put a conical piece of paper in the path of the ray of light to obtain the proper conical illumination without much trouble.

H. S. GEORGE: I think with the new (Bausch and Lomb) system you might simply do that by stopping the central rays, but you would not be able to rotate the direction of light and get it from all directions, unless you were able to rotate the beam by rotating the bulb.

CHAIRMAN P. D. MERICA: There is an additional feature which seems to me to be of value in the suggestion made by Mr. George. I think many of us have noticed with certain lenses, that there is a reflection from the back lens of the objective which makes work with certain lenses—I have in mind particularly an 8-millimeter lens, and the old Leitz microscope—almost useless. The device of cutting out the central rays will entirely eliminate that, and at the same time, owing to the fact that you use the peripheral rays, will give you the same resolving power.

F. B. FOLEY: I would like to ask Mr. George if that scratch he used for reference there, was made purposely or is it an incidental scratch?

H. S. GEORGE: It is just a scratch that happened to be there.

O. W. ELLIS: (Written discussion) The advantages of the new method of lighting for microscopic examination and photomicrography described by H. S. George are remarkably demonstrated in the photomicrographs of the unetched sections and of the slip bands and grain boundaries in ferrite. There is no doubt that the method will lend itself particularly to the examination of deformed samples of pure metals. Could Mr. George state how much additional exposure is required to meet the diminution in the intensity of illumination occasioned by the introduction of the disks between the light source and the object?

The writer has one criticism to make with regard to the term "conical illumination." Is not this term a misnomer? Vertical illumination is more truly conical illumination than is the type of illumination described by Mr. George since his device eliminates the center of the solid cone of light used in the more common types of illuminators, and results in what might be more aptly described as "periconic illumination." Might I suggest the use of the term "periconic" in lieu of the term "conical?"

H. S. GEORGE: (Written discussion) It appears to me on reading the stenographer's report on the oral discussion that there were one or two questions brought up to which I should have given more explicit answers. In the original paper, it was stated that a Bausch and Lomb inverted metallurgical microscope was used. It was not until the paper had been published that I learned of the new illuminating system of Bausch and Lomb which utilized an incandescent filament mounted close to the microscope proper. It was not until the day before reading the paper that I had the opportunity of inspecting the new illuminating apparatus. In the original paper there should have been included a description of the source of light used, which was a Leitz automatic arc lamp, adapted according to the writer's design to the Bausch and Lomb illuminant stand.

It would appear that the new Bausch and Lomb design solves, in a very satisfactory way, the difficulties encountered with the hand feed type of arc lamp, but it is doubtful whether it would be suitable for use with conical illumination, on account of the shape of the light beam—a narrow horizontal band—unless a rotating stage be employed, or unless the beam of light could be rotated. The value of conical illumination is largely dependent upon the ability of the operator to vary at will, not only the degree of obliquity of the illuminating rays, but also the direction from which light comes to the object. The degree of obliquity is controlled by the size and eccentricity of the stop, being limited by the numerical aperture of the objective. The direction of the incident beam is changed by rotating the eccentrically placed disk about the optic axis. The importance of being able to change the direction of lighting cannot be emphasized too much.

The remark of Dr. Merica on the possible corrective effect of stopping out central rays, is very interesting. His deduction is undoubtedly correct and adds very materially to the value of conical illumination.

I wish to thank Mr. Lynch and Prof. Boylston for their remarks, and to confirm Prof. Boylston's impression that conical illumination is just another tool for metallographic research. The question which Prof. Boylston raises, as to whether I think that the new method should replace other methods, I can only answer by saying that in my own work, the method is used exclusively in connection with the 16-millimeter, 4-millimeter and oil immersion objectives. Each metallographist will, of course, have to decide for himself what method to use for his own particular purposes. My reason for using the method exclusively in connection with the lenses mentioned, is that it reveals everything that the other methods do, and also information which is not revealed by the other methods. I use the method both for examination of metal structures which present relief and for those which do not, for I consider it of value for purposes of record, as in photomicrographs, to know what the structure looks like under conical illumination, even though no additional information may be

revealed, than to wonder how the structure would have looked, had it been taken under conical illumination.

Replying to the written discussion of Prof. O. W. Ellis, I would say, in answer to his question, that introducing the stop in the beam of light does not necessarily diminish the intensity of illumination below that which would ordinarily be employed with so-called vertical illumination. In vertical illumination, the iris is usually closed very considerably, whereas in conical illumination, the iris is usually opened to almost its full extent and the stop is then inserted and manipulated until the most desirable position is found by trial. The resulting intensity of illumination may be greater, equal, or less than that used in vertical illumination, but is usually about equal.

The suggestion of the term "periconic" in lieu of the term "conical" which Prof. Ellis makes, I see no particular objection to, and I must admit that the problem of finding a suitable name for the new method is a difficult one. The names for the ordinary method of illumination, "axial" or "vertical" are not strictly correct, and their use constitutes to my mind one of the reasons why the method discovered by the writer was not used a long time ago, because they give the impression that the light is really vertical or axial. I cannot quite agree with Prof. Ellis that the shape of the light beam in the new method is not that of a hollow cone, and I think he will agree with me, that a cone can be either a solid or a surface. However, the point seems to be well taken in his remark, that so-called axial illumination is more truly conical than the new method.

NOTES FROM THE U. S. BUREAU OF STANDARDS

Non-Destructive Test of Wire Rope

AN INVESTIGATION of the possibility of developing a non-destructive test for wire rope in housing service has been under way at the Bureau of Standards since July, 1923. This investigation was mentioned in paragraph 10 of *Technical News Bulletin* 75.

At a meeting of the advisory committee for this investigation, it was decided that methods involving magnetic testing should be given first consideration. It has been found necessary to obtain certain fundamental information not heretofore available before proceeding with the design of field apparatus. It was necessary first to consider the effect of stress on magnetic properties, since a hoisting rope in place is always under stress of varying magnitudes, according to the position of the load.

A method of analysis has been discovered which appears to be capable of indicating the relative proportions of the material which are under tension and under compression. This work has also demonstrated, apparently, that the difficulty heretofore experienced in attempting to find the laws of correlation between magnetic and other physical properties can be attributed to the effect of stress, as the magnetic properties are very sensitive to this influence.

Preliminary work has also been done on the effects of the magnetic properties of various factors causing deterioration of the steel wire from which the rope is made.

A progress report covering this investigation has been prepared and submitted to members of the advisory committee.

The Cold Working of Metals

During the past month questions in connection with the effect of temperature of rolling upon the hardness changes induced by cold deformation of metals have received considerable attention. Zinc was rolled at a temperature of 15 degrees Cent. The specimens were kept in a freezing mixture of salt and ice except while being passed quickly through the rolls at a temperature of from zero to 2 degrees Cent. The low temperature did not affect the general form of the scratch and Brinell hardness curves but the material itself became more brittle with initial deformation than has usually been found to be true. Work in connection with the determination of the density changes of copper after cold rolling is being continued. This procedure is rather slow, however, since the material must be given a series of cold rolling after each density determination.

Mechanical Properties of Metals at Elevated Temperatures

The Bureau of Standards is constructing an apparatus for "long-time" tension tests to supplement equipment already available for studying the high temperature properties of metals. This new equipment will be used primarily to determine the limiting loads which can be used at different temperatures with the several types of materials already tested by ordinary methods of tension and compression. At the request of the joint committee on phos-

phorus and sulphur in steels, arrangements are under way to make short time tension tests at temperatures of from 20 to 1200 degrees Cent., on four of the steels used by the committee which contain varying proportions of sulphur. At the request of the special committee of the American Society for Testing Materials work has been started on the preparation of a report entitled "Available Data on the (Mechanical) Properties of Irons and Steels at Various Temperatures." This will form part of a topical discussion of the properties and applications of metals for high and low temperature service which will be held at the spring meeting of the American Society of Mechanical Engineers in Cleveland, Ohio., under the auspices of that society and the American Society for Testing Materials.

The Wear Testing of Metal

Some of the work which the Bureau of Standards has conducted on the determination of the wear of metals was described some time ago in the *Bulletin*. At that time it was pointed out that a considerable difference in the rate of wear resulted when the abraded particles were removed from the specimen and when these were allowed to accumulate. The device designed for cleaning the specimens during a run has been tried out and proved quite successful. The previous results as to the difference between rate of wear when the particles are removing and when they are not were corroborated. When these particles are removed the amount of wear is so small in some cases—2 or 3 milligrams per hour, that it will be necessary to make runs of several hours duration in order to get comparative quantitative data.

The Question Box

A Column Devoted to the Asking, Answering and Discussing of Practical Questions in Heat Treatment — Members Submitting Answers and Discussions Are Requested to Refer to Serial Numbers of Questions

NEW QUESTIONS

QUESTION NO. 116. *Can a zinc bath be used as a heating medium in substitution for a lead bath? If not, what are the objections to its use?*

QUESTION NO. 117. *Does cooling molten metal rapidly eliminate segregation?*

QUESTION NO. 118. *Is a small percentage of chromium desirous in carbon tool steel? What is its advantage or disadvantage?*

QUESTION NO. 119. *What is the advantage of sulphuric acid as a quenching medium?*

ANSWERS TO OLD QUESTIONS

QUESTION NO. 83 *In annealing high-carbon tool steel in an open-fire furnace* 6 *feet x* 12 *feet is it likely that sulphur would be imparted to the steel by the use of producer gas made from coal unusually high in sulphur, say around* 1.50 *to* 2.00 *per cent?*

ANSWER. By Dr. C. M. Johnson, director of research and metallurgical departments, Crucible Steel Co. of America, Park Works, Pittsburgh.

It is a well known fact that steel lying in solid fuel rich in sulphur, will absorb the sulphur, however, steel annealed in an atmosphere of producer gas containing some sulphur, may not ab-

sorb sulphur on account of the scale that is formed during the process in open fire annealing. It would be a simple matter however to settle the point under local conditions by chemically analyzing for sulphur the drillings taken close to the surface of the steel specimen and comparing the results obtained with those drillings taken at ⅛ and ¼ inch below the surface.

QUESTION NO. 93. What are the more common methods of quenching ordinary taps? Are they quenched all over and the shanks drawn, or are they quenched only on the threaded portions; or are both the threaded portions and the tangs quenched, leaving the center portion of the shanks soft?

QUESTION NO. 96. Can the structure of a piece of steel be determined by the microscope applied to the fracture of a cross section, without polishing and etching the fracture, say of a stamping die 6 x 2 x 3½ inches, that has been hardened and broken in half, that is, are the different structural phenomena known as austenite, martensite, sorbite, ferrite, etc., so determinable?

QUESTION NO. 98. What heat treatment will give a pure martensite structure throughout the hardened area of a piece of steel 6 x 2 x 3½ inches?

QUESTION NO. 99. What is the effect of barium carbonate and sodium carbonate in carburizing compounds on alloy carburizing boxes?

ANSWER. By J. S. Ayling, metallurgical engineer, Cleveland.

Neither sodium nor barium carbonate, in the amounts usually present in commercial carburizing compounds, have any serious effect on alloy carburizing boxes, particularly where the energizers are properly fixed to the material by impregnation or other suitable methods. A large excess of either chemical, not in intimate contact

with the compound, or used at temperatures in excess of 1750 degrees, Fahr. might produce noticeable amounts of $BaCrO_4$ or Na_2CrO_4, and as $BaCrO_4$ is the more easily formed of the two, barium would undoubtedly have the greater effect.

However, the writer has not seen any failures of alloy boxes which were positively shown to be due to either $BaCO_3$ or Na_2CO_3, the pots failing from other causes long before any slight action which the energizers might have in seriously damaging the container.

The information obtained from a number of metallurgists using alloy boxes with a compound containing 7 to 9 per cent Na_2CO_3, impregnated, positively states that they have been unable to discover any detrimental effect on the container after years of service in actual production.

ANSWER. By Gordon A. Webb, Rodman Chemical Company, Verona, Pa.

The barium and sodium carbonate contents of commercial carburizing compounds has no effect on alloy carburizing boxes.

When the general run of luting clays is used, the eating away of the alloy box around the rim and cover is caused by the clay and not by the barium and sodium carbonate in the carburizing compound. (See answer to question number 103.)

Failure of the alloy boxes due to other causes such as the so-called "cancer growth," etc., is due entirely to some fault within the alloy itself, such as segregation of the elements of which it is composed, improper pouring temperatures, or improper foundry practice, etc., and not to the use of barium and sodium carbonate as energizers in the carburizing material.

Most of the alloy box manufacturers acknowledge that barium and sodium carbonate, when used in carburizing compounds, have no effect on their alloy boxes.

QUESTION NO. 100. *What action results from the addition of varying amounts of aluminum and ferrosilicon to steel while casting?*

ANSWER. By Larry J. Barton, consulting engineer, New Orleans.

Assuming, in this instance, that *casting* means the actual pouring of the metal into the mold, there are certain conditions which will change the action of the alloy.

1. Where the steel is "wild."

In this situation the effect of the additions will be a rapid combination with the oxygen present, the result being to promote solidity to the metal. The necessary quantity to add to obtain this condition will depend directly upon the amount of gas or oxide contained in the steel. The combination will result in a considerable amount of the solids, silica and alumina which will be distributed, in very small particles, throughout the body of the casting. In cases where the metal is very hot these inclusions will work themselves toward the upper sections resulting in the so-called sand spots, and defects on the cope side, so familiar in steel casting work.

2. Where the steel is thoroughly sound.

If the metal is hot, ferrosilicon will mix in all proportions up to the point where its further addition so chills the metal that melting is impossible. This will depend upon the size of the casting poured and the initial temperature of the steel itself. As the percentages of silicon in steel increases, the first noted effect will be an apparent sluggishness to the metal, the steel having a creamy appearance, yet having the ability to run very thin-sectioned castings. The solidity of the metal increases, as does the shrinkage, while the size of the grains change from the fine textured, close crystalline structure, to a large sized crystal having a very bright, platey appearance. As the percentage of silicon passes 0.70 to 0.80 per cent the castings will become "tender" and great care must be exercised to prevent losses from cracking.

Aluminum added to already sound steel greatly increases the shrinkage, with no benefits. The metal has the same creamy, sluggish appearance as with silicon.

QUESTION 103. *What is the effect of clay luting on alloy carburizing boxes?*

ANSWER. By Gordon A. Webb, Rodman Chemical Company, Verona, Pa.

W. E. Blythe answered this question in the January, 1924 issue

of TRANSACTIONS, and we believe he is correct in his statement that most of the clays used for luting carburizing boxes will attack nickel-chromium boxes around the rim.

However, there is a question as to whether luting clays may be entirely done way with, and we believe that a properly designed cover, well luted on, will reduce the burning, and consequent shrinkage of the carburizer.

Special clay luting materials for luting carburizing boxes, such as are manufactured and available on the market, will not attack any of the nickel-chromium, or other alloy carburizing boxes, and on continued use will leave the rim and lid of the boxes perfectly clean.

QUESTION NO. 106. *What are the effects of the products of combustion upon both carbon and high-speed steel, when heat treated in open furnaces heated with city gas, coal, coke, fuel oil, etc?*

QUESTION NO. 109. *What are hairline cracks and how may they be detected?*

ANSWER. By Harold F. Wood, chief metallurgist, Ingalls-Shepard Division, Wyman Gordon Co., Harvey, Ill.

Hairline cracks, more commonly known as hairline seams, are caused by small gas inclusions in the steel being elongated during rolling. A true hairline seam has nothing whatever to do with nonmetallic inclusions, and does not indicate that excessive nonmetallic inclusions are present. They are caused by the steel being improperly deoxidized.

Hairline seams may be detected by taking transverse and longitudinal sections of the forging bar, polishing the surface of same, and etching the grain flow by boiling for one hour in 20 per cent solution of hydrochloric acid.

They may also be detected by turning the forging bar to a round section, grinding same to a smooth finish, and etching as above.

QUESTION NO. 110. *Do notched bar impact specimens give more uniformly constant results than an un-notched bar?*

QUESTION NO. 111. *How is the reduction of area a flat tensile test specimen usually obtained?*

QUESTION NO. 112. *What quality of lead should be used in lead baths for heat treating steels?*

ANSWER. Commercial pig lead seems to give about the same results when used in lead baths, for the heat treating of steels as do some of the special grades of lead which are on the market and sold especially for lead pot work.

Two elements sometimes found in lead which may cause the lead to adhere to the stock are tin and sulphur. Tin even though present in small amount, will cause considerable trouble by adherence, therefore in selecting lead for lead bath work, it is essential that the tin content be exceedingly low.

QUESTION NO. 113. *How does the use of aluminum as a deoxidizer affect the quality of the steel produced?*

ANSWER. By J. Barton, consulting engineer, New Orleans.

Aluminum, under any class of circumstances, can only be considered as a dope, and should never be used unless in extreme cases. If the metal is "wild" it is perfectly true that the use of aluminum will give a sound casting, but the quality of the metal is not there, and while the steel may show a great freedom from the familiar blowholes, it contains a large amount of alumina distributed throughout its mass, each particle forming a point of weakness. Then there is the question of dissolved oxide, which aluminum will not eliminate, resulting in considerable cracking, especially at the corners of a casting. Steel killed with aluminum should never be poured into anything but the cheapest kind of a casting.

Aluminum added to sound steel only results in increasing the shrinkage, not only in the heads, but in the body of the casting where they cannot be found, and where they later come to light

as a piece of defective material. The making of first class steel is an easy matter without the use of any such powerful deoxidizer as aluminum, and its use is but an admission of faulty melting practice.

QUESTION NO. 114. *Is it possible to obtain an accurate conversion table for obtaining Brinell hardness number from the Rockwell or scleroscope values?*

QUESTION NO. 115. *How is the fiber stress of a shaft calculated? Is there a relation between fiber stress and tensile strength and if so, can the fiber stress be estimated if the tensile strength is known?*

Abstracts of Technical Articles

Brief Reviews of Publications of Interest to Metallurgists and Steel Treaters

THE DEVELOPMENT OF MODERN STAMPING PRACTICE. By W. W. Galbraith and John R. Winter, president and superintendent of the Youngstown Pressed Steel Co., Youngstown, O., in the *Journal* of the American Society of Mechanical Engineers, January, 1924, page 17.

In this paper the authors discuss the early uses of pressed metal and the use of pressed steel in the automobile field, as well as the replacement of cast parts and various applications. They state that it is not the aim of the pressed metal manufacturer to eliminate castings but to draw attention to the great advantage in cost and time that can be gained by the use of pressed metal.

DEVELOPMENT OF POWER PRESSES. By H. J. Hinde, president of the Toledo Machine and Tool Co., Toledo, O., in *Iron Age,* Jan. 3, 1924, page 22.

This article deals with the remarkable progress made in the past 25 years in the use of large power presses. Illustrations of the machines and some of the stampings are shown.

INDIVIDUAL HEAT TREATMENT TO IMPROVE QUALITY. By C. N. Dawe, metallurgical engineer, Studebaker Corporation, Detroit, in *Automotive Industries,* Jan. 24, page 177.

This paper points out that the remarkable production of today has resulted in heat treating in large quantities, although there are often complaints made with reference to the nonuniformity in treatment, the greatest difficulty being with small parts. To overcome this, a particular furnace has been designed for piston pins, another for shackle bolts, etc. Photographs and diagrams are given.

RECENT DEVELOPMENTS IN STEEL FORGING. By John L. Cox, in *Forging, Stamping and Heat Treating,* January, 1924.

This paper was presented before the American Iron and Steel Institute in October, 1923, and is a review of the developments in the line of forging exceptionally large machine parts and points out that forgings are often employed to advantage in place of steel castings.

REVIEW OF IRON AND STEEL LITERATURE FOR 1923. By E. H. McClelland, Technology Librarian, Carnegie Library of Pittsburgh, in *Forging, Stamping and Heat Treating*, January, 1924.

This is a five-page tabulation in a classified list of the more important books, serials and trade publications appearing during the past year; also including a few of an earlier date which had not previously been announced.

SOME EFFECTS OF BRAZING AND WELDING. By H. C. Knerr, metallurgical engineer, Philadelphia, in *Forging, Stamping and Heat Treating*, January, 1924.

The author discusses the application of heat in brazing and welding and its effect in reducing the strength produced by the original cold working of the material. The effect of heat treatment on brazed and welded steel is also discussed.

ECONOMIC PHASES OF COAL STORAGE. By F. G. Tryon and W. F. McKenney, U. S. Geological Survey, Washington, in *Mechanical Engineering*, Vol. 46, No. 2, February, 1924.

This paper is a discussion of the storage of coal and the extent to which the practice of storage has already been adopted. A discussion of how much coal the consumer should store is considered according to periodic price fluctuations and coal supply.

DATA ON ALUMINUM ALLOYS FOR AIRPLANE STRUCTURAL WORK. By Fred H. Colvin, in *American Machinist*, Vol. 60, No. 7, Feb. 14, 1924.

This paper discusses the use of aluminum alloys in airplane construction and goes into considerable detail on the minor construction of channels, struts, and the placing of rivets and bolts.

EXPLOSION OF DUSTS IN AIR. By L. J. Trostel and H. W. Frevert, in *Chemical and Metallurgical Engineering*, Vol. 30, No. 4, Jan. 28, 1924.

In this article, the authors recount some recent tests made at the Bureau of Chemistry, Department of Agriculture, and interpret the investigations made in the light of industrial needs.

IMPORTANCE OF CHROMIUM TO THE CHEMICAL ENGINEER. By C. B. Bellis, in *Chemical and Metallurgical Engineering*, Vol. 30, No. 4, Jan. 28, 1924.

This paper discusses in some detail the metal chromium and its various uses in the industrial field, pointing out its use as in nickel-chromium alloys and chromium-irons, etc.

RUST RESISTANCE OF NICKEL-PLATED STEEL. By Edwin M. Baker, in *Journal* of Society of Automotive Engineers, Vol. 14, No. 2, February, 1924.

The author points out that the quality of plated steel may be tested by exposing the article to the action of a salt spray and noting the appearance at intervals. A numerical method of rating the appearance is given, and the rust resistance of steel plated with nickel and copper is shown to be dependent on the thickness of the plating. The need of close technical control of the plating process is indicated, and some of the advantages of controlled electroplating at high current densities are set forth.

THE TERMINAL VELOCITY OF PARTICLES OF POWDERED COAL FALLING IN AIR OR OTHER VISCOUS FLUID. By John Blizard, in *Journal* of the Franklin Institute, Vol. 197, No. 2, February, 1924

This paper is a technical discussion involving numerous formulas and discusses the terminal velocity acquired by a particle of coal falling in a combustion chamber of a furnace and points out that terminal velocity is an important factor in determining the rate at which the particle burns.

PHOTOMICROGRAPHY AND TECHNICAL MICROSCOPY IN ITS APPLICATION TO TELEPHONE APPARATUS. By F. F. Lucas in the Bell System *Technical Journal,* Vol. 3, No. 1, January, 1924.

The author discusses both generally and specifically the application of the microscope to the study of materials used in the production of telephone materials and equipment. It is a very complete discussion of microscopy and contains much valuable information. Discussion of high power photomicrography and photomicrography by means of polarized light is likewise included.

ALLOYING NICKEL WITH CAST IRON. By P. D. Merica, in *Iron Trade Review,* Feb. 21, 1924.

This paper studies the results obtained by the additions of nickel in varying percentages to cast iron, and indicates that the hardness is increased and that the grain structure is made more dense. Observations relative to the effect of nickel additions to iron and how this should be made and what results may be expected, are discussed in detail, also the limitations of the nickel-iron alloys are presented.

FERRO-ALLOYS. By F. M. Becket, in *Chemical and Metallurgical Engineering,* Vol. 30, No. 5, Feb. 4, 1924.

This paper is the first of a series of three which discusses the work the author has done on this subject and which was the basis of his being awarded the 1923 Perkin Medal. The uses of ferrosilicon in the industry are discussed in some detail.

Reviews of Recent Patents

By
NELSON LITTELL, Patent Attorney
110 E. 42nd St., New York City
Member of A. S. S. T.

1,467,669 and 1,467,670. Furnaces for the Heat Treatment of Metals. Lyman C. Josephs Jr., of Allentown, Pa., and Gottfried Wirrer, of Plainfield, N. J., assignors to International Motor Co. of New York, a corporation of Delaware.

These two patents relate to heat-treating furnaces especially designed for use with a method of heat treatment described by these inventors in prior patent applications, wherein the determination of the critical point of the metal being treated is dependent upon the rate of change of dimension of the metal and in which the change in the heat treatment is initiated through a change in the rate of change of dimension of the metal.

The furnace disclosed in the first patent is composed of a pair of parallel elongated chambers, one for hardening and one for drawing. Passages, controlled by suitable dampers permit the heat to pass from the hardening chamber to the drawing chamber, so that no extra heat need be applied to the drawing chamber. The hardening chamber is provided with contact rails at the top and bottom, and the different sections of the contact rails are connected to different transformers to get different temperatures. The articles to be treated, such as shafts, axles, or the like, are mounted between suitable contact shoes at the top and bottom of the chamber so as to be heated by their own resistance and are moved step by step through the hardening chamber by means of a cable. After passing through the hardening chamber the articles are automatically received by a turntable, plunged into a quenching bath and returned to the cable to be moved through the tempering chamber.

The latter patent 1,467,670 shows a revolving table or turret which carries the articles being treated on the arms of the turret which may be elevated to insert the articles into electrically heated muffles for hardening and tempering and which may be depressed to plunge the articles supported thereon into a quenching bath. The turret is rotated by the step by step movement and is elevated and depressed in proper sequence to effect the transfer of the articles from the hardening to the quenching or tempering chambers by means of automatic controls. Means are provided in the last hardening chamber whereby as the article in that chamber passes through its critical point the change in the rate of change of dimension of the article is utilized to auto-

matically set in motion the control mechanism for effecting a one-step transfer of all the articles on the arms of the turret.

1,468,937. Alloy Steel and Articles Made Therefrom. Percy A. E. Armstrong, of Loudonville, New York, assignor to Ludlum Steel Co., of Watervliet, N. Y.

This patent describes a new alloy steel for use where steel of unusually high strength is desired and which is particularly adapted for impact tools such as chisels, punches or the like. The inventor states that the alloy has a quenching range for hardening from about 1500 degrees to 2100 degrees Fahr. and that the higher the quenching temperature within this range, the harder will be the article. A specific composition of the alloy, by way of example is: Carbon 0.35 per cent, manganese 0.50 per cent, silicon 0.30 per cent, chromium 1.25 per cent, tungsten 2.10 per cent, vanadium 0.30 per cent, iron 94.84 per cent, sulphur 0.015 per cent, phosphorus 0.015 per cent, copper 0.08 per cent.

1,469,374. Method of Making Wrought Iron. James Aston, of Pittsburgh, assignor to A. M. Byers Co. of Pittsburgh.

This patent relates to a method of preventing "red shortness" in wrought iron, when manufactured in accordance with the inventor's process, wherein a molten steel product is poured into a slag bath to granulate the metal and the wrought iron puddle ball formed therefrom. According to the inventor the "red short" condition may be eliminated or reduced by adding to the molten steel product before it is mixed with the slag, a protective metalloid, such as silicon or phosphorus, which probably acts to prevent the "red shortness" by protecting the metal from the ferric oxide content of the slag. In the practice of the invention about 1 per cent of ferrosilicon containing 17 per cent silicon is added to the molten steel product.

1,469,706. Method of Treating Molten Metals. Calvin Vos.

This patent claims a method of treating molten metal with suitable alloys or degasifying agents which differs from the common method of introducing thermit or the like into the metal by having it in a can on the end of a suitable tool, in that the present invention molds the alloy to be added into a cylindrical shape, with a tapered hole therethrough, drives a rod or tool into the tapered hole and plunges the molded alloy or scavenger on the end of the tool through the slag and into the molten metal.

1,469,761. Ingot of Refractory Metals and Method of Making Same. John A. Yunck, of South Orange, N. J.

This patent discloses a process of producing ingots of tungsten or of tungsten and thorium. The finely powdered tungsten is packed in a cylinder of copper or the like and the end of the cylinder closed by means of a suitable plug. These cylinders are preferably about 1¼

inches in diameter and have a wall thickness of ⅛ inch. The packed cartridge or cylinder after the ends are sealed is swaged down to about ⅜ inch, while cold or only moderately heated, and a number of the elongated cylinders are then packed into a tube of graphite, through which a heavy current of electricity may be passed to first raise the temperature inside the tube high enough to vaporize the copper envelope around the tungsten and then to a temperature of about 2750 degrees Cent. to fritter the particles of tungsten together, after which the carbon tube is permitted to cool slowly and the elongated ingots withdrawn.

1,471,190. **Process of Producing Soft Ferrous Metal Castings.** Hubert **A. Myers of Toledo, O., assignor to the Hubert A. Myers Co.** of Toledo, **O.**

This patent relates to the production of soft ferrous metal castings in relatively permanent (metal?) molds. The process proposed, comprises pouring the ferrous metal into a heated mold, discharging the casting, after the skin has solidified, and while the casting is still at a temperature in excess of 1300 degrees Fahr., onto a conveyor which carries the casting slowly through a heated lehr wherein the temperature is gradually reduced to below 900 degree Fahr. The theory of operation seems to be, that the carbon which has combined with the solid iron to form Fe_3C will be liberated during the slow cooling to form a soft graphite grey iron structure.

1,471,563. **Carburizing Compound and Process of Making and** Using It. **Stanley B. Mathewson and Walter K. Jamison of Springfield, O., assignors to Walter K. Jamison et al, Trustees of the Lecar** Carbon **Co., a Trust Estate.**

This patent describes a process of carbonizing leather, leather scrap, etc., by placing the same in a sealed container in a furnace heated to 1200 degrees Fahr. at which point the heat is turned off and the furnace permitted to cool slowly for about six hours, at the end of which time, the containers are opened and the carbonized leather removed and ground to suitable fineness for use as a carburizing compound. The patent then describes carburizing or case hardening S. A. E. 1020 steel of ¾-inch section by holding the steel when packed in this compound for five hours, in a furnace heated to 1700 degrees Fahr. The patent states that the compound produces a very deep case in a minimum of time. The claims of the patent are for a carburizing compound containing fixed carbon, volatile matter, moisture and ash.

News of the Chapters

SCHEDULED REGULAR MEETING NIGHTS

FOR the convenience of visiting members, those chapters having regular meeting nights are listed below. It is desired that all secretaries whose chapters are not included in the list communicate with the National office in order that the list may be as complete as possible.

Boston—Third Thursday.

Cleveland—Fourth Friday, Cleveland Engineering Society rooms, Hotel Winton; meeting at 8 p. m.

Chicago—Second Thursday.

Hartford—Tuesday nearest 10th of month.

New Haven—Third Friday.

New York—Third Wednesday, assembly room, Merchants Association of New York, ninth floor, Woolworth building.

Philadelphia—Last Friday, Engineers' club.

Tri City—Third Thursday.

BOSTON CHAPTER

THE Boston chapter of the American Society for Steel Treating held a meeting on Jan. 17, at the Massachusetts Institute of Technology at 7:30 p. m. About 250 members and guests were present to hear Prof. P. A. Heymans, the speaker of the evening, deliver a most interesting address entitled, "Photo-elasticity." Professor Heymans described the application of the methods of photo-elasticity to the study of stress variation in fabricated parts. There were also autochrome colored slides shown to illustrate this paper. After the presentation, those present were invited to inspect the testing materials, metallographic and heat treatment laboratories of the institute.

The chapter held their February meeting on the twenty-first at the Blake and Knowles plant of the Worthington Pump & Machinery Co. The program for this meeting opened with plant visitation at 3:30 p. m., and at 6:30 p. m. dinner was served. John H. Nelson, research engineer, Wyman and Gordon Co., Worcester, Mass., was the speaker of the evening choosing for his subject, "The Response of Certain Steel to Heat Treatment with a Discussion of Flow Lines in Forging." Much valuable discussion following the presentation of Mr. Nelson's paper.

CHICAGO CHAPTER

The regular monthly meeting of the Chicago chapter of the American Society for Steel Treating was held on Feb. 14 at the City club. "The Annealing of Tool Steel" was the title of a practical illustrated talk given by

J. V. Emmons, metallurgist, Cleveland Twist Drill Co. Inasmuch as Mr. Emmons has made a life study of this particular phase of tool steel, he gave a very capable presentation, which brought forth much valuable discussion. W. H. Eisenman, national secretary, also was present at this meeting and spoke to those in attendance of the coming events the society has planned. Dinner was served at 6:30 p. m. preceding the meeting.

CINCINNATI CHAPTER

The Cincinnati chapter of the American Society for Steel Treating held their regular monthly meeting on Tuesday evening, Feb. 12, at the Ohio Mechanics institute. H. F. Moore, professor of engineering, materials testing laboratory, University of Illinois, Urbana, Illinois, gave a very interesting address entitled, "The Fatigue of Metals." Prof. Moore has designed several machines for testing the strength of engineering materials and devices for measuring changes of form of structure. Considerable interesting and instructive discussion followed this presentation.

CLEVELAND CHAPTER

The Cleveland chapter of the American Society for Steel Treating held their regular monthly meeting on Feb. 29 at the Cleveland Engineering Society rooms, Hotel Winton, at 8 p. m. "Carbon Tool Steel and High-Speed Steel Used in the Manufacture of Small Tools," was the title of a very interesting address given by A. H. d'Arcambal, metallurgist, Pratt & Whitney Co., Hartford, Conn. This paper was well illustrated with samples and lantern slides and was discussed from the viewpoint of the user rather than the maker of the steel. Mr. d'Arcambal is well known to many of our members and his paper was well received. This meeting was very well attended. Dinner was served at 6:45 p. m. preceding the meeting.

HARTFORD CHAPTER

On Wednesday, Feb. 13, the Hartford chapter of the American Society for Steel Treating held their regular monthly meeting at the Hartford Electric Light Co., building. L. A. Lanning, metallurgist for the New Departure Manufacturing Co., Meriden, Conn., was the speaker of the evening and gave an interesting illustrated paper entitled, "Quality Heat Treatment as Carried Out in the Ball Bearing Industry." This presentation covered the methods used in carrying out the heat treatment and the precautions taken by the metallurgical department in the production of a high grade product; and brought forth much valuable discussion. Dinner was served at the University club at 6:30 p. m. preceding the meeting.

DETROIT CHAPTER

The Detroit chapter of the American Society for Steel Treating held a meeting on Monday, Feb. 25 in the General Motors building at 8:00 p. m. "Carbon and High Speed Steels Used in the Manufacture of Small Tools" was the title of an address given by A. H. d'Arcambal, metallurgist, Pratt & Whitney Co., Hartford, Conn., Mr. d'Arcambal is an authority on this subject and gave a very capable presentation, which was illustrated with a number of specimens and slides. Supper was served at 6:30 p. m. preceding the meeting.

There are some of our members who are gloriously gifted with talent for other things than the "ites," "oids," "micros" and "macros" as pertaining to their daily duties, and occasionally indulge in such endeavors as the following. In this case, the Detroit chapter has the distinction of having a poet-metallurgist among its membership.

The Hardener's Friend

Bill was an expert, the best thereabout,
As a toolmaker Bill was the goods without doubt.
Why, I overheard men in the toolroom there, too,
Say that Bill forgot more than the boss ever knew.

Now Jim was in charge of the hardening room
Where the toolmaker's work was sent to its doom.
So Bill said, that day he explained to the bunch,
All there was to heat treatment of steel, there at lunch.

But Jim sat and grinned as Bill's theory ran low
All he said was, "Well, boys, took me ten years or so
To find out there's a lot that I yet have to learn
Perhaps Bill here could give me advice that I yearn."

Then Bill said to Jim "Now, remember this too
When you carburize tool steel to heat it clear through.
Let it soak in the furnace till it shows cherry red,
Then quench it in oil but be sure, Jim" he said—

"To draw back the temper a minute or two
Then remove from the bath when it shows a sky blue."
"Time to go Jim," said Bill, as he turned to the bunch,
"Only too glad to help you any time after lunch."

Bill told in the toolroom that day to his crew
That a toolmaker had to know hardening, too.
"Why," said he, "just suppose Jim had gone right ahead
And spoiled all our tools 'fore I showed him," he said.

But alas for poor Bill, for the toolmaker's trade
Left its mark on his brow from the worries it made.
With his tools put away Bill just said, "I'm a fool
For the jack of all trades masters none as a rule."

L. J. Roberts,
1309 Military Ave.,
Detroit, Mich.

INDIANAPOLIS CHAPTER

The Indianapolis chapter of the American Society for Steel Treating held a meeting on Feb. 11 at Hoosier Athletic club at 8:00 p. m. H. G. Breckenridge, National Tube Co., Pittsburgh, presented a very interesting paper on "The Manufacture of Shelby Seamless Tubing and Shelby Seamless Cylinders." Two reels of motion pictures, as well as a number of slides, were shown depicting the various phases of the manufacture of tubing. The meeting was very well attended, dinner being served at 6:30 p. m.

LOS ANGELES CHAPTER

The Los Angeles chapter of the American Society for Steel Treating held their regular monthly meeting on Wednesday evening, Feb. 6, 1924 in the assembly room of the Westinghouse building, Fourth and San Pedro streets, Los Angeles, Cal.

After a brief business meeting, the speaker of the evening was introduced. W. F. Farrar, district sales agent for E. F. Houghton & Company products in California, gave a very interesting and instructive talk on "The Uses and Applications of Quenching Oils." A very enthusiastic discussion followed the presentation. About 65 members and guests were present.

NEW HAVEN CHAPTER

On Friday evening, Jan. 18, the New Haven chapter of the American Society for Steel Treating held an open meeting at which time the members were offered the opportunity of discussing problems and difficulties with which they meet. The meeting was held at the New Haven Gas Light Co.

NEW YORK CHAPTER

The New York chapter of the American Society for Steel Treating held a joint meeting with the New Jersey Chemical society on Monday, Jan 14 at Stetter's restaurant, Newark, N. J. Jerome Strauss, Metallurgist, Naval Gun Factory, Washington, and chairman of the Washington chapter presented a paper on "Stainless Steel," which brought forth much valuable discussion. A four-reel film entitled, "Story of Alloy Steel" was shown through the courtesy of the Bureau of Mines. Dinner was served at 6:15 p. m. preceding the meeting.

The chapter held their regular monthly meeting on Tuesday, Feb. 19, at the Machinery club, 50 Church street, New York City, at 8:00 p. m. Bradley Stoughton, professor of metallurgy, Lehigh university, gave an illustrated address on "The Heat Treatment of Cast Iron." This paper was very well received and brought forth much valuable and instructive discussion.

The New York chapter of the American Society for Steel Treating is distinguished by having as a new member, Miss Ethel M. Bailey, the first woman member to join the society.

Miss Bailey was born in Houlton, Maine, Aug. 18, 1896 and received her education in the public schools of Portland, Maine, the Boston School of Physical Education, the Michigan State Automobile School, Detroit and the George Washington university, Washington, where she took a special

Ethel M. Bailey

course. Her experience in the business world has been as follows: Aircraft Production Service, stationed at Detroit district equipment office; transferred to Holbrook plant of the Cadillac Automobile Company for test field training. She was then sent to Nordyke-Marmon plant, Indianapolis, in charge of test field office and club calibration. A short time later she was connected with the Cadillac Automobile Co. of Boston, in charge of technical service, then as assistant to the head of the specification and material section of the Bureau of Construction and Repair, Aircraft Division of Navy. Miss Bailey is now employed with the L. W. F. Engineering Co., Inc., College Point, N. Y., in charge of material testing.

Miss Bailey is also a member of the Society of Automotive Engineers, the American Society for Testing Materials, and the Aeronautical Chamber of Commerce.

NORTH WEST CHAPTER

The North West chapter of the American Society for Steel Treating held their regular monthly meeting on Wednesday evening, Feb. 20 at

8:00 p. m. at the Manufacturers' club. V. A. Hain, Chicago district manager of the George J. Hagan Co., Pittsburgh, addressed those in attendance on "Furnaces and Their Uses." Mr. Hain is well qualified to discuss this subject, inasmuch as the company he represents manufactures a number of different types of heat treating furnaces, including gas, oil, powdered coke and electric. His presentation which was illustrated, was very capably given.

PHILADELPHIA CHAPTER

On Friday evening, Feb. 29, the Philadelphia chapter of the American Society for Steel Treating held a meeting at the Engineers' club, at which time Major A. E. Bellis, president of the Bellis Heat Treating Co., New Haven, Conn., gave an illustrated lecture on "Heat Treatment in Salt Baths." Major Bellis who is an authority on the subject, spoke of some of the advantages claimed for the use of molten salts as a heating medium in the treatment of steel tools and similar high grade parts. Much discussion followed this presentation.

"Shops Kinks in Sheet Steel" was the title of a practical talk given by Dr. George L. Kelley, metallurgist, Edward K. Budd Manufacturing Co., Philadelphia. Dr. Kelley is well known and his address was very well received.

PITTSBURGH CHAPTER

The Pittsburgh chapter of the American Society for Steel Treating held their March meeting on the fourth of the month in the Hawaiian room of the William Penn hotel. R. J. Allen, chief metallurgist, Rolls-Royce Co. of America, Inc., Springfield, Mass., gave an illustrated address entitled, "The Inspection and Testing of Materials for Automotive Purposes." This presentation brought forth much instructive discussion. Dinner was served at 6:30 p. m. preceding the meeting. On Thursday evening, Feb. 21, the chapter held their first annual dinner dance at the Chatham hotel. A very pleasant evening was spent by those in attendance.

SPRINGFIELD CHAPTER

The Springfield chapter of the American Society for Steel Treating held a meeting on Tuesday, Feb. 19, at the chamber of commerce rooms. L. A. Lanning, metallurgist for the New Departure Manufacturing Co., Meriden, Conn., was the speaker of the evening, choosing for his subject, "Quality Heat Treatment as Carried Out in the Ball Bearing Industry." This talk was illustrated and covered the methods used in carrying out the heat treatment of high grade bearings.

F. P. Gilligan, Henry Souther Engineering Co., Hartford, Conn., gave a short talk on the aims and activities of the national organization. A get-together dinner was served at the Highland hotel at 6:30 p. m. preceding the meeting.

SYRACUSE CHAPTER

The Syracuse chapter of the American Society for Steel Treating held a meeting on Feb. 22 at the Hotel Yates at 8:00 p. m. John Halbing, superintendent of heat treating, Willys Morrow Co., Inc., Elmira, N. Y., was the speaker of the evening, choosing for his subject, "Methods versus Human Element in Heat Treating." Considerable discussion followed this presentation.

TRI CITY CHAPTER

The night course given under the auspices of the Tri City chapter of the American Society for Steel Treating, and which has been in session for the past 17 weeks was brought to a close on Feb. 13. This has been entirely a lecture course and there have been a number of exceptionally good talks given during this time. Each member was taxed a registration fee of $3.00 with the condition that this would be returned at the conclusion of the course, provided his attendance was 100 per cent and the equipment used had not been demolished. It has been interesting to note that 37 per cent of the membership received the refund of $3.00. The average attendance per meeting was approximately 75 per cent. Those who took the course have stated that it has been very much worth-while and beneficial to them.

WASHINGTON CHAPTER

The Washington chapter of the American Society for Steel Treating held a meeting on Friday, Feb. 15 in the auditorium of the New Interior Department building. An illustrated address entitled, "Giving Steel Tools a Chance" was given by F. R. Palmer, Carpenter Steel Co., Reading, Pa. Mr. Palmer's talk covered the general practice of handling tool steels and aroused much interesting discussion.

ADDRESSES OF NEW MEMBERS OF THE AMERICAN SOCIETY FOR STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A represents Associate Member; S represents Sustaining Member; J represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective.

ADAM, WM. (M-2), heat treater, Watertown Arsenal, Watertown, Mass., *mail,* 279 Belmont street, Wollaston, Mass.

ADAMS, J. R. (M-2), superintendent research department, Midvale Co., Nicetown, Philadelphia.

ADVANCE PYROMETER SERVICE CO. (S-2), W. H. Leary, president, Chicago.

BAILEY, LYNN H. (M-2), distributor E. F. Houghton & Co., Chicago, *mail,* 1900 South Seventh avenue, Maywood, Ill.

BATTY, R. (Jr-2), 2507 North Marshall street, Philadelphia.

BECK, G. P. (A-10), Brown Instrument Co., Boston.

BIERLY, G. M. (Jr-1), 766 Bedford place, Columbus, O.

BOWEN, J. M. (M-12), tool designer, Worthington Pump & Machinery Co., Boston, *mail,* 47 Hall place, West Quincy, Mass.

BRUSHINGHAM, R. M. (A-8), salesman, Colonial Steel Co., Chicago.

BUSH, A. A. (M-1), superintendent mechanical production, Firestone Tire & Rubber Co., *mail,* 44 Lake street, Akron, O.

CAPEN, D. A. (M-2), manager, Sanderson Works, Crucible Steel Company of America, Syracuse, N. Y.

CARLSON, E. (M-2), laboratory assistant, Watertown Arsenal, Watertown, Mass., *mail,* 11 Silloway street, Dorchester, Mass.

CARLSON, G. O. (M-2), superintendent cylinder department, Wm. Wharton, and Sons Co., *mail,* 1916 Ferry street, Easton, Pa.

CHRISTENSEN, C. (M-2), assistant foreman, Nash Motors Co., *mail,* 790 Engel street, Kenosha, Wis.

CLAFFEY, J. B. (Jr-1), 606 North Sixty-fourth street, Philadelphia.

CLARK, J. F. (M-2), assistant superintendent, Bethlehem Steel Co., Reading, Pa., *mail,* 120 Park road, Wyomissing, Pa.

COLLINS, Wm. F. (M-2), tool hardener, Carr Fastener Co., Cambridge, Mass.

CONRATH, B. F. (M-2), inspection engineer, American Steel Foundries, *mail,* 607 Douglas avenue, Hammond, Ind.

COOK, E. V. (M-12), foreman heat treating department, Willys Morrow Co., *mail,* 714 Kinyon street, Elmira, N. Y.

COOPER, C. A. (A-2), salesman Halcomb Steel Co., *mail,* 6010 Glenwood avenue, Chicago.

COOPER, E. C. (M-2), chemist, American Steel Foundries, Granite City, Ill., *mail,* 623 Veronica street, East St. Louis, Ill.

CORSE, Wm. M. (M-2), consulting metallurgist, International Nickel Co., New York City and National Research Council, Washington, *mail,* 1901 Wyoming avenue, Washington.

CRAMER, R. E. (M-2), research metallurgist, U. S. Ball Bearing Co., Chicago.

DAVIS, G. L. (A-1), district manager, Calorizing Co., Detroit.
DITTMAR, H. (M-2), metallurgical laboratory, Central Steel Co., Massillon, O.
DIX, E. H. (M-2), research bureau, Aluminum Company of America, New Kensington, Pa.
DOCHERTY, G. C. (M-1), service department, Leeds & Northrup Co., Philadelphia, *mail*, R. F. D. No. 1, Smith's Creek, Mich.
FOULKES, T. G. (M-2), plant representative, Bethlehem Steel Co., Bethlehem, Pa.
FOX, R. R. (M-2), president Simonds Saw & Knife Agency, *mail*, 416 East Third street, Los Angeles, Cal.
GEITZ, G. (M-2), foreman machine shop, Pheoll Mfg. Co., Chicago.
GENERAL ALLOYS Co., (S-12), 405 West First street, Boston.
GREENE, H. D. (M-12), sales manager, Houghton & Richards, Inc., *mail*, 145 Oliver street, Boston.
GREENWOOD, J. (Jr-12), heat treater, American Engineering Co., Philadelphia, *mail*, 6120 Cottage street, Wissinoming, Philadelphia.
GREGSON, G. E. (M-2), steel treater, Morse Twist Drill Co., *mail*, 75 Lake street, New Bedford, Mass.
GREVILLIUS, G. T. (M-12), works manager, Grant Gear Works, *mail*, 151 Pearl street, Boston.
GORDON, A. A. (M-2), assistant metallurgist, Crompton-Knowles Loom Works, *mail*, 26 Sagamore road, Worcester, Mass.
GRUNDLER, H. A. (Jr-2), student, Case School of Applied Science, *mail*, 1275 East 115th street, Cleveland.
HAMMOND, C. P. (Jr-1), student, Temple University, *mail*, 5832 North Sixth street, Philadelphia.
HARSH, J. W. (M-1), metallurgist, Leeds & Northrup Co., Philadelphia.
HAWKRIDGE BROTHERS COMPANY, (S-2), L. D. Hawkridge, vice president, Boston.
HECKEL, J. E. (A-2), service engineer, Wilson-Maeulen Co., Pittsburgh.
HELLEBUSH, C. J. (M-12), metallurgical department, Dodge Brothers Co., *mail*, 4511 Commonwealth avenue, Detroit.
HELMQUIST, A. (Jr-12), 15 A. Madison street, Cambridge, Mass.
HIBBLER, M. I. (M-2), tool superintendent, Shur-On-Optical Co., *mail*, 230 Andrews street, Rochester, N. Y.
HOFFMEYER, H. C. (M-2), 15723 Holmes avenue, Cleveland.
HOUCK, R. A. (M-2), Electric Manganese Steel Co., Reading, Pa.
HOUGHTALING, G. (M-2), Hickok Mfg. Co., Rochester, N. Y.
HULT, O. G. (M-2), hardener, Perfection Tool Hardening Co., Chicago.
KILLMER, J. K. (M-12), steel treater, Bethlehem Steel Co., *mail*, 530 High street, Bethlehem, Pa.
KING, J. A. (A-1), sales engineer, Carborundum Co., Boston, *mail*, Box 744, Worcester, Mass.
KINZEL, A. B. (M-2), metallurgist, Henry Disston & Sons Co., Philadelphia.

KONOLD, J. R. (Jr-2), Massachusetts Institute of Technology, Cambridge, *mail,* 515 Beacon street, Boston.

KNERR, Wm. J. (M-1), metallurgical division, Bethlehem Steel Co., Bethlehem, Pa., *mail,* 708 Turner street, Allentown, Pa.

LANGE, A. (M-2), foreman in tool forge department, Westinghouse Electric & Mfg. Co., East Pittsburgh, *mail,* 643 Southern avenue, Pittsburgh.

LEARY, W. H. (S-2), president Advance Pyrometer Service Co., Chicago.

LEWIS, J. I. (M-1), Ingersoll-Rand Co., Phillipsburg, N. J., *mail,* 53 North Third street, Easton, Pa.

LITTLEFIELD, F. E. (M-2), toolsmith hardener, Lundin Electric Manufacturing Co., *mail,* 75 Prospect avenue, Wollaston, Mass.

LORENZ, G. E. (M-2), manager, American Heat Treating Plant, Philadelphia.

LUCAS, H. (M-2), trouble man, tool division, Studebaker Corp., *mail,* 312 South William street, South Bend, Ind.

MAACK, H. (M-2), chemist, Doehler Die Casting Co., Batavia, N. Y.

MASTRI, F. (M-2), superintendent melting department, Columbia Steel Corp., Pittsburg, Cal.

MCGUIRE, J. T. (M-2), assistant production superintendent, Stromberg-Carlson Telephone Co., *mail,* 1050 University avenue, Rochester, N. Y.

MOLLOY, J. A. (M-2), materials man, betterment department, American Rolling Mill Co., Middletown, O.

NEMSER, D. A. (M-2), chemist and metallurgist, Pratt & Whitney Co., *mail,* 456 Washington street, Hartford, Conn.

PAECHT, Wm. (M-1), chemist, Crucible Steel Company of America, Harrison, N. J., *mail,* 19 Prospect Place, Brooklyn, N. Y.

PROPES, I. R. (M-2), superintendent, National Enameling & Stamping Co., *mail,* 2234 "C" street, Granite City, Ill.

RAPATZ, DR. I. F. (M-2), chief research engineer, Stahlwerk Dusseldorf, *mail,* Oberkassel, Bohler Werk, Dusseldorf, Germany.

RIENER, C. (M-1), foreman Delta File Works, *mail,* 155 East Ellen street, Philadelphia.

ROMER, J. B. (M-2), 210 Elm street, Elizabeth, N. J.

ROSENBERG, F. P. (M-1), heat treating department, Columbia Steel Corp., *mail,* Box 295, Pittsburg, Cal.

RYAN & Co., F. J. (S-12), 540 Flatbush avenue, Hartford, Conn.

SAWYER, C. B. (M-1), secretary, Brush Laboratories Co., Cleveland.

SEGAL, D. (M-2), chemist, Hupp Motor Co., *mail,* 1774 Seward avenue Detroit.

SHAFFER, S. (M-2), in charge of annealing tool steel, Midvale Company, Philadelphia.

SILBERSTEIN, (M-2), metallurgical engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, *mail,* 401 Barnes street, Wilkinsburg, Pa.

SIMPSON, D. J. (M-2), foreman hardening department, Chicago Screw Co., Chicago.

SMITH, F. W. (M-2), 518 Avenue "L", Bethlehem, Pa.

TREW, C. W. (M-1), superintendent sheet mill, Columbia Steel Corp., *mail*, Hotel Los Medanos, Pittsburg, Cal.

UNDERWOOD, P. G. (M-12), manager manufacturing department, Graff-Underwood Co., *mail*, 18 Beacon street, Somerville, Mass.

VANATTA, L. H. (M-2), laboratory assistant, Ingersoll-Rand Co., Phillipsburg, N. J., *mail*, 23 Belvidere avenue, Washington, N. J.

WAMBACH, M. (Jr-2), Trevose, Pa.

WARDLE, A. (M-11), heat treater, Standard Seamless Tube Co., *mail*, 187 Fifth street, Ambridge, Pa.

WETHERELL BROS. CO. (S-12), 251 Albany street, Cambridge, Mass.

WHEELOCK, LOVEJOY CO., INC., (S-2), Cambridge, Mass.

WILLIAMS, W. E. (A-2), salesman, Swan & Finch Co., *mail*, 764 Oakwood boulevard, Chicago.

WOOD, C. L. (M-12), president and treasurer, Thermal Engineering Corp. *mail*, 72 Moffat street, Brooklyn, N. Y.

WOOD, T. F. (A-2), branch manager, Halcomb Steel Co., Syracuse, N. Y., *mail*, 222 Edinburgh street, Rochester, N. Y.

WOODSON, J. C. (M-1), section engineer, Westinghouse Electric & Mfg. Co., *mail*, 341 Avenue, East, Westinghouse Plan, East Pittsburgh, Pa.

YOUNG, J. (M-2), foreman tool hardening department, Ingersoll-Rand Co., Phillipsburg, N. J.

ZIMMERMAN, R. (M-2), metallurgical department, Ingersoll-Rand Co., Phillipsburg, N. J., *mail*, 15 South Eleventh street, Easton, Pa.

MAIL RETURNED

ARLOVIN, U. A., U. S. Steel Products Co., 156 Central avenue, Los Angeles.
AVON, A. J., 548 Jackson avenue, Jersey City, N. J.
BOYD, C. F., Nordyke & Marmon Co., Indianapolis.
CHERRY, R. M., 103 N. Fiftieth street, Philadelphia.
CLARKE, W. E., Calorizing Company, Detroit.
FALES, H. G., Emmons apartments, Huntington, W. Va.
GLAB, PETER, 260 Tremont street, Syracuse, N. Y.
HEIL, O., Aluminum Company of America, Cleveland.
LANNON, J. D., 8 Glenwood avenue, Pontiac, Mich.
LOWE, R., 147 Varick street, New York City.
MOERS, W., Hughes Tool Co., Los Angeles.
PECK, C. A., 605 Warren street, Flint, Mich.
SCHULTZ, C. H., 4021 Northminster street, Pittsburgh.
WEISE, A. M., Marlin Fire Arms Corp., New Haven, Conn.

Items of Interest

DOCTOR Albert Sauveur, professor of metallurgy and metallography at Harvard university has been awarded the 1924 Bessemer Gold Medal of the Iron and Steel Institute of Great Britain. Leave of absence has been granted Doctor Sauveur so that he may go to London to receive the

DR. ALBERT SAUVEUR

medal at the May, 1924, meeting of the institute. He will spend several months abroad.

Professor Sauveur is the first American in 29 years to receive the Bessemer medal, although he is the sixth resident of this country to be so honored "in recognition of eminent services in the advancement of the science of iron and steel." The medal, founded in 1874, first came to the United States in 1879, when Peter Cooper received it. The other American recipients are Alexander L. Holley (1882), Abram S. Hewitt (1890), John Fritz (1893), and Henry Marion Howe (1895).

Dr. Sauveur is an honorary member of the American Society for Steel Treating.

Dr. H. W. Gillett has been appointed, effective March 1, chief of the division of metallurgy of the United States Bureau of Standards, which has been vacant since Dr. George K. Burgess was made director of the bureau. Dr. Gillett was graduated from Cornell university in 1906, receiving his degree of doctor of philosophy later. He installed the research department of

the Aluminum Castings Co., Cleveland, and for the past 11 years has been in charge of the Ithaca field office, Ithaca, N. Y., of the Bureau of Mines, devoting much of his time to electric brass furnaces and ferrous and nonferrous alloys. His work in connection with the development of a well-known type of electric brass melting furnace and his contributions to both nonferrous and ferrous metallurgy are some of the products of his career in recent years.

Eugene G. Grace, president of the Bethlehem Shipbuilding Corp., recently made public the following facts regarding the operations of the corporation in 1923:

During the year 1923 the ship repair business of the Bethlehem Shipbuilding Corp., Ltd., showed an increase over 1922 of 22 per cent in number of ships repaired, of 23 per cent in tonnage of ships repaired and of 25 per cent in billings per ship repaired.

The Bethlehem Shipbuilding Corp., Ltd. is a subsidiary of the Bethlehem Steel Corp., handling the shipbuilding and ship repairing work of the corporation in addition to constructing passenger railroad cars, American designed diesel engines, and special machinery for shipping and industrial purposes.

Shipbuilding has declined throughout the world during the past few years. According to a recent statement by Lloyd's Register, world ship construction for last year was less than a quarter of that for the record year 1919 when 7,144,000 gross tons of merchant shipping was sent down the ways.

On the other hand, that the old ships are gradually wearing out is indicated by the steady increase in Bethlehem's repair business. The ships repaired by the Bethlehem plants last year were registered at a tonnage of 9,748,872, or equivalent to 59 per cent of the total merchant marine tonnage of the United States.

The number of the ships repaired in the past three years in the Bethlehem yards with their total tonnage was:

Year	Number of Ships	Tonnage
1921	1158	4,674,000
1922	1983	8,005,000
1923	2415	9,748,000
Total	5556	22,427,000

From the point of view of dollars and cents the above repair work would be about equivalent to the complete construction of 30 steel cargo vessels of an average tonnage of 5000 tons.

During 1923 Bethlehem constructed in her various yards 25 steel vessels of 45,854 gross tonnage, of which 15 were for strictly commercial uses, including cargo ships, tankers, ferry boats, barges and car floats.

On the first of January, 1924, Bethlehem had under construction, or under contract to build for private ship owners, 14 steel ships of a gross tonnage of 17,500.

Frank G. Davis, formerly with the Iroquois Steel Co., Buffalo, joined on Feb. 1, the sales force of the Carpenter Steel Co., with offices at 520 West Congress street, Detroit.

(*Continued on Page 34 Advertising Section*)